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EFFECT DATE OF EXPLANT TAKING AND PLANT GROWTH REGULATORS ON MICROPROPAGATION OF *Cestrum nocturnum* L.

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ABSTRACT

This study conducted in laboratory tissue culture to propagation *Cestrum nocturnum* L. form *vegetative shoots* including shoot tips, node segments and *Floral buds* at 5 stages newly setted bud partly swollen bud, totally swollen and non flushed buds and initially flushed buds, which were excised and culture on MS medium in the experience of the dates. The best date to take explant was in August and April, where explants were able to survive after treatment with disinfectant. The highest percentage of response of plantlets from shoot tips and nodal segments were at 82.33% and 95% respectively in August. The highest number of proliferation 2 shoot from shoot tips and 2.67 shoots from nodal segments in the April and the longest of proliferation of shoots from shoot tips and shoot from nodal segments in April and August (2.23-2.03) and (2.50- 2.40) cm respectively. While The floral bud collected on various date (day) on different growth stage and culture on MS medium containing 0.01 mgl^{-1} IBA and 250 mgl^{-1} L-Glutamine for two weeks The highest percentage of response of plantlets from Partly swollen at 60% and Responded bud and the nature of response 85% developed into flower from Initially flushed The plantlet taken to completion the next stage and the subsequent culture on MS medium supplemented with different concentration of BA at (0, 0.5, 1, 1.5 and 2) mgl^{-1} combine with (0, 0.5, 1, 1.5 and 2)mgl^{-1} Kin using node segments and shoot tips as explant. BA at 0.5mgl^{-1} combine with 2 mgl^{-1} Kin produce the highest number of proliferation shoots as 3.5 from node segments and 3 from shoot tips when cultured on MS medium containing 1 mgl^{-1} BA+1.5 mgl^{-1} Kin and in the same medium the explant gave the highest number of leaves 6.50 leaves/ node segment and 5.10 leaves/ shoot tips. Elongated shoots of Cestrum were rooted on half strength MS medium supplemented with NAA and IAA at (0, 0.2, 0.5 and 1) mgl^{-1} alone. NAA and IAA at low concentration (0.5 mgl^{-1}) increased the number of developed roots, and the root length (5.8 root/ shoot and the root length 7.5 cm) and (3.7 root/ shoot and the root length 4.7 cm) receptivity. The plantlets of Cestrum were transferred from rooting medium and cultured in pots containing peat moss and sand (1:1 by volume) under greenhouse conditions. The plants grow normally and the survival percentage reached 100%.

KEY WORDS: Cytokinin (BA and Kin), Cestrum , Micropagation and plant growth regulators.

2. INTRODUCTION

Cestrum nocturnum L. belonging to the family Solanaceae. It is native to tropical America and the West Indies. *Cestrum* also known as Night Blooming Jessamine, is grown in subtropical regional as an ornamental shrub plant for is stangly – scented. This is a popular landscape shrub in warm climates. For a mixed border, back ground, or as a free standing species, Night Blooming Jessamine is altercative and unpretentious. Propagation practices utilizing and *in vitro* technique are presently employed with many plants. In the case of woody plants such as apple, grape and cherry, the techniques have found commercial uses (Dodds, 1983).

The methods of *in vitro* propagation of plants can broadly be classified in to two groups. The first is to use shoot apices, shoot tips and axillary buds as explants, and this a useful means for rapid clonal propagation production of virus-free plants and preservation of genetic resources. The second group of *in vitro* propagation is to utilize adventitious embryos or buds formation in callus or even directly from somatic tissue. The latter is very useful for rapid mass production or in such from in compatible crosses. With regard to the species belonging of *Cestrum*, both of above methods have been examined in the several studies (AL-Mizory, 2007).

Most of the researches used nodal segments, shoot tips, petioles, ect., for mass production. Arshad *et al.*(2005) established micropropagation protocol for *Bombuas wamin* by using nodal explant from 10 -12 year old trees, and succeeded in getting multiple shoots and rooting in the MS medium supplemented with 2 mgl^{-1} BA and 0.8 mgl^{-1} Kin and 7.5mgl^{-1} IBA for rooting. Datta *et al.* (2007). Regenerated multiple shoots from nodal explants of *Jartropha cucras* on MS medium supplemented with 5 mgl^{-1} Kin as 3.5 shoots /nodal explants.

While most of the researches used another explants for the development of somatic

embryos of plants, for instance, (Bekheet *et al*., 2004) used non ripen flower buds(Aly Mam *et al.* 1992 ; Miah et al. 2002), used ripen and non ripen ovaries as explants and Gambino *et al*. (2007) non ripen complete flower when cultured on MS medium with different combinations growth regulators with amino acids to stimulate the emergence of somatic embryos, for instance, MS medium supplemented with 2 mg / l BA, 1 mg / l Kin, 0.01 mg / L IBA, 250 mg / L glutamine used for development of somatic embryos of plants (Tulecke and McGranahan, 1985; Tulecke *et al*. 1988). Charoensub and Phansiri (2004) observed the rate of shoot multiplication of Rose Colared Leadwart (*Plumbago indica* L.), which varied significantly during date culture. Chu and Huang (1983) developed an efficient protocol for micropropagation of *Gerbera hybrid* Hort. On MS medium supplemented with 10 mgl^{-1} BA. Shah *et al*. (2006) developed an efficient protocol for propagation of *Bougainvillea spectabilis* by using MS medium supplemented with 0.25 mgl^{-1} BA and 1 mgl^{1}Kin. The micro shoots were rooted on growing medium supplemented with low concentrations of auxins 2 mgl^{-1} IBA and or NAA and reduced concentration of sucrose 2.5% (Nasib *et al*. 2008).

The aim of study was establishment of primary culture to timed taken effect of explant and to data of taking effect of explant and to determine the best concentration of CKs on shoot multiplication and auxins on in vitro propagation of *Cestrum nocturnum* L. plant.

3. MATERIAL AND METHODS

This study was carried out in Plant Tissue culture Laboratory in the Department of Horticulture College of Agriculture and Forestry, University of Mosel, during (July/2010 – June/2011). Explant (10 cm) collected from healthy, disease–free and actively plant growth in the field after pruning. Explant was washed thoroughly under running tap-water in the laboratory to reduce the dust and surface contaminations. Surface sterilization of the explant was done by treating them with 70% ethanol for 1 min and followed by 0.6 % sodium hypochlorite solution (containing 5.25% sodium hypochlorite) for 10 min (AL-Mizory, 2007) under aseptic condition laminar air flow cabinet for obtaining aseptically explants and to remove every trace of the sterile explants was washed with sterile distilled water at 3-4 times. Both end of the explants exposed to sterile were trimmed and the explant were placed aseptically 250 ml jar containing 50 ml MS medium supplemented with 2 mgl^{-1} BA for two weeks transferred to the same medium for taking date for different months. This study included many experiments:

2.1. The first experiment: The effect of date collecting of shoots:

Explant were collected on various date for 6 months (in the second weeks of every month from mother plant). After remove the leaves, shoots were cut into small pieces (1cm) each with shoot tips and node segment to used as explants then cultured on MS medium (Murasige and Skoog, 1962) supplemented with 2 mgl^{-1}BA, 30 gl^{-1} sucrose and 7 gl^{-1} agar-agar. After 4 weeks data accorded to the percentage of survival, number of shoots and shoot length (cm) Fig. (1, 2 and 3) to avoid of contamination

3.2. The second experiment: Effect growth stage of Floral buds:

The floral bud collected on various date (day) on different growth stage were included four groups containing 40 buds on a different growth stage (age for a days) such as newly setted bud (2-4 days), partly swollen bud (6-8 days), totally swollen and non flushed buds (10-12 days) and initially flushed buds (14-16 days), they were inoculated on MS medium supplemented with 2 mgl^{-1}BA, 1mgl^{-1}Kin, 0.01mgl^{-1} IBA and 250 mgl^{-1} L-Glutamine under dark condition to differentiation somatic embryogenesis for two weeks, then sub-culture to another fresh MS medium containing 0.01 mgl^{-1}IBA and 250 mgl^{-1} L-Glutamine for two weeks under 16h light/8h dark condition (L.D.)long day. Then after 8 weeks the swollen bud Re-cultured on MS medium containing 0.01 mgl^{-1}IBA with 3gl^{-1}activeted charcoal to stimulate the growth of cells swollen ovaries and thus may obtain somatic embryos, especially since the ovaries contain one of the stages in its growth on the fabric, which is characterized by its ability Alniossila high on the composition of somatic embryos. The parameter of this experiment according after 4 weeks : The percentage of responded buds (% developed to shoots, % developed to flower and % their ovaries were swollen).

3.3. The third experiment: Effect of cytokinin on shoot proliferation:

After 4 weeks the explants from the shoot tips, node segment and floral buds when development to the shoots transferred to the multiplication medium. The shoot longest >1.5

cm cutting in 1cm containing shoot tips and node segment then explant were placed in 25× 150 mm^2 culture tube containing 15-20 ml MS medium supplemented different concentration and combination of (0.0, 0.5, 1.0, 1.5 and 2.0) mgl^{-1} BA plus (0.0, 0.5, 1.0, 1.5 and 2.0) mgl^{-1} Kin. After 6 weeks of culture: The number of shoots, number of leaves and shoot length (cm) were recorded.

3.4. *The fourth experiment: Effect of Auxin on shoot rooting:*

The shoots more than (1.5 cm) transferred to the rooting stage and cultured on ½ strength MS medium supplemented with different concentration of NAA and IAA at (0.0, 0.2, 0.5,1.0) mgl^{-1} alone. The parameter of this experiment according after 4 weeks data were reccording stage at rooting percentage, the number of root per shoot and root length(cm).

The pH of all medium was adjusted to 5.7 ± 0.1 after addition of agar at 0.7% and sucrose at 30 gl^{-1} concentrations .The media were dispended into culture tubes and autoclaved at 121ºC under 1.1Kg/cm^3 pressure for 20 min. Cultures were maintained at 25 ± 1ºC with 16-h photoperiod providing light intensity at 1000kux.

4. RESULTS AND DISCUSSION

3.1. Effect of date of taking explants:

At this stage MS medium supplemented with 2 mgl^{-1} BA was very effective medium on producing shoots from the both explants when culture on a various months.

The producing shoot highly. shoot proliferation obtained from shoot tips and node segments which significantly enhanced when cultured on MS modified medium. Differences among the treatments on percentage of shoots number per explants and shoot length were found to be significantly (Fig 1, 2 and 3) and (Fig 4 a, b). The highest percentage of shoot response (95%) were recorded from node when cultured on MS medium supplemented with 2 mgl^{-1} BA in August and (83.3%) for shoot tips on the same medium in the September. While the lowest percentage of response (39.67%) in June (Fig1), on the other hand, the highest number of shoots per explant show in (Fig 2). The highest number of proliferation (2. 67 and 2) from node segment and shoot tips, respectively in April.

The Fig (3) showed that MS medium supplemented with 2 mgl^{-1}BA obtained the longest shoot proliferation from nodal segments and shoot tips in Apr and August (2.5- 2.4) cm and (2.23- 2.03) cm, respectively. While the lowest length of shoots (1.43) cm from shoot tips in Jul month. Hameed *et al*. (2006) reported that high concentration of cytokinin reduced the number of micropropagation shoots of *Rosa indica* L., similar results have already been in Chrysanthemum by (Jevremovic *et al.* 2006). Also the results are in consistent with the findings of *Fragraia X ananassa* Duch. (Sakila *et al.* 2007) as well as in *Tilia platyphyllos* scop. (Üçler and MollamehmetoĠlu, 2001).The developing shoots were elongated by culturing on the same concentration of growth regulators. Later on elongated shoots were excised and used for multiple shoot induction.

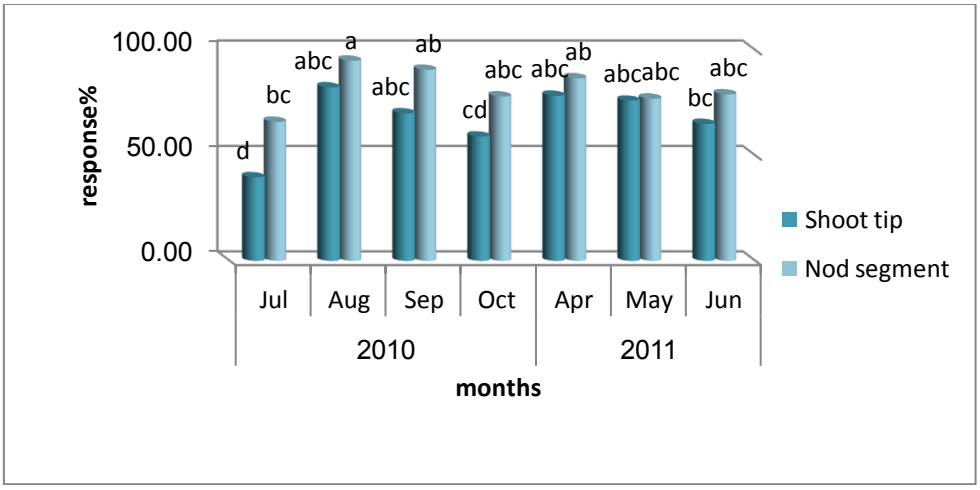

Fig.(1):- Effect of (collecting time) months on the percentage of response of plantlets from shoot tip and node segments cultured on MS medium + 2 mgl^{-1} BA after 4 weeks.

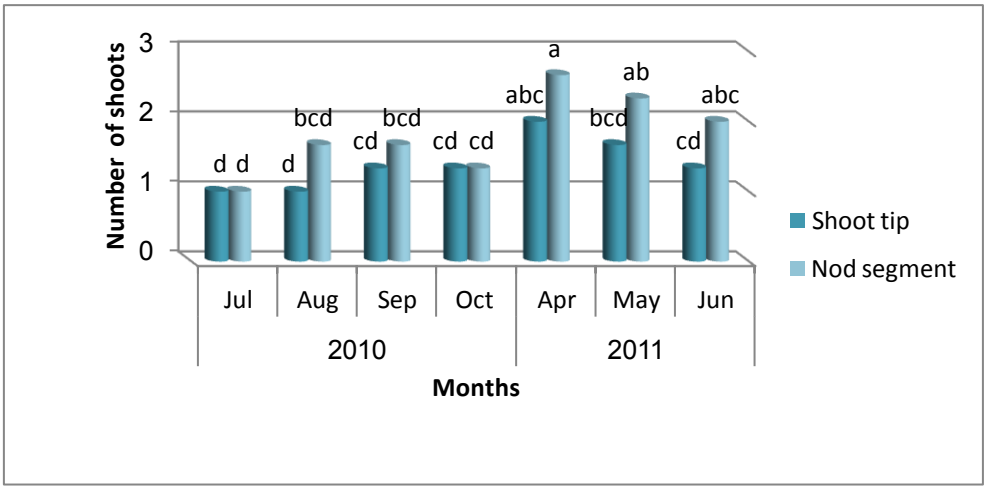

Fig.(2):- Effect of (collecting time) on the shoot proliferation of shoots from shoot tip and node segments cultured on MS medium + 2 mgl^{-1} BA after 4 weeks.

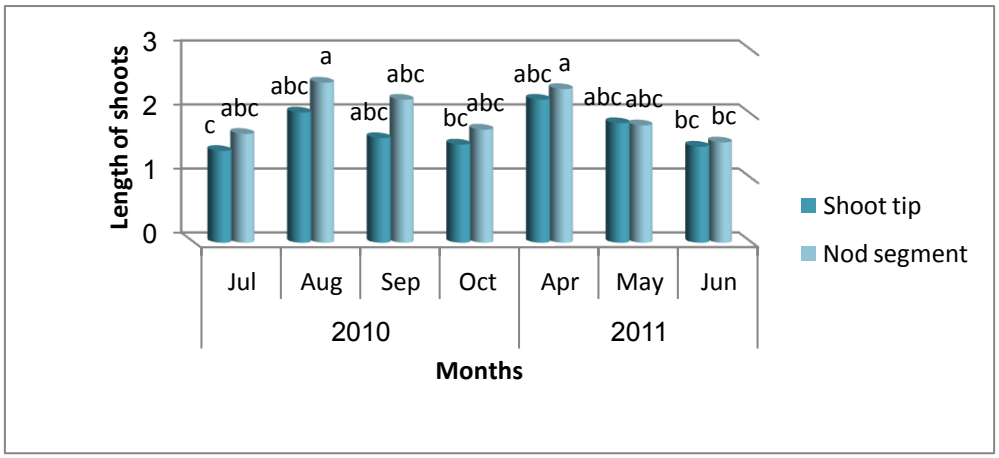

Fig.(3):- Effect of (collecting time) months on the length of shoots from shoot tip and node segments cultured on MS medium + 2 mgl^{-1} BA after 4 weeks.

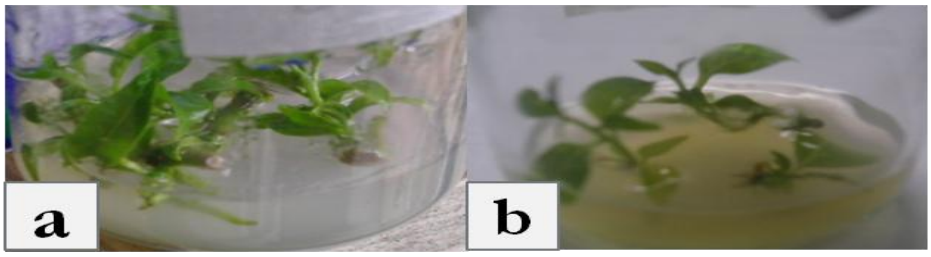

Fig.(4) *In vitro* shoot proliferation from a) node segments b) shoot tips on MS medium + 2 mgl^{-1}BA in August and September respectively after 4 weeks

3.2 Effect of date collecting of Floral buds:

At this Experiment, MS medium supplemented with 2 mgl^{-1}BA+ 1mgl^{-1}Kin+ 0.01mgl^{-1} IBA and 250 mgl^{-1} L-Glutamine was used for culture floral buds which were collected on various dates at different growth stages. The highest percentage of non responded buds (60%) was recorded from partly swollen buds. Whereas, the lowest response percentage (0%) was recorded from initially flushed buds (Table 1, Fig 5). Then the explants were transferred to another fresh MS medium containing 0.01 mgl^{-1}IBA and 250 mgl^{-1} L-Glutamine for two weeks under 16 h light daily. After 4 weeks in culture, the highest responded buds and the nature of response per explant were recorded. (Fig 5.) The highest response percentage (85%) was recorded from initially flushed and developed buds into

flowers and 60% from totally swollen and non flushed buds where developed to their ovaries were swollen and (55%) from newly set buds and developed into shoots. While the lowest percentage of response (0%) was recorded from initially flushed and not developed buds to flowers and their ovaries were swollen, while concerning the transformed buds or developed into shoots, the initially flushed buds do not developed into shoots but they were developed into flowers and their ovaries were swollen at high rates (Fig 5 a, b, c and d).

The reason for turning most of the newly set and partly swollen to shoot may be due to the influence of a high concentration of cytokinin during stimulation the growth of somatic embryos, which led to overcome their impact on the hormonal effetc in these buds and converted to the growth of syphilis to the vegetative growth. These findings are consistent with the findings of (AL- Judges, 1997; AL-Mizory, 2007 and Al- Noh, 2009) when propagated *Gardenia jasminoides*, *Cestrum nuctornum* L. and *Chrysanthemums* respectively. As for the growth of a large proportion of initially flushed buds to flowers prefix openness may return to that GA_3 has completed its impact on the buds and thus paid to the growth of syphilis. Did not result in swollen floral buds growing on MS medium processor of 0.01 mg l^{-1} IBA and with 3 gl^{-1} activated charcoal to the growth of somatic embryos and this may be due to the lack of appropriate interactions added to the MS medium for the development of somatic embryos.

Table (1):- Response to the growth of floral buds of *Cestrum nocturnum* L. on modified MS medium after 4 weeks of culture**.**

Bud growth stage	***Bud age*** (***day***)	***Non responded bud%***		***Responded bud and the nature of response***					
				Developed into sl		***Developed into f***		***Their ovaries were***	
		No.	%	***No.***	%	***No.***	%	***No.***	%
Newly setted	$2-4$	18	$45a$	22	$55a$	0	$0c$	0	$0b$
Partly swollen	$6-8$	24	$60a$	12	$30b$	2	$5c$	2	$5b$
Totally swollen and non	$10-12$	8	$20b$	0	$0c$	5	$20b$	24	$60a$
Initially flushed	$14-16$	0	$0c$	0	$0c$	34	$85a$	6	$15b$

* Means followed by the same letter within a column do not differ significantly (α=0.05) according to Duncan's Multiple Range Test (Duncan ,1955).

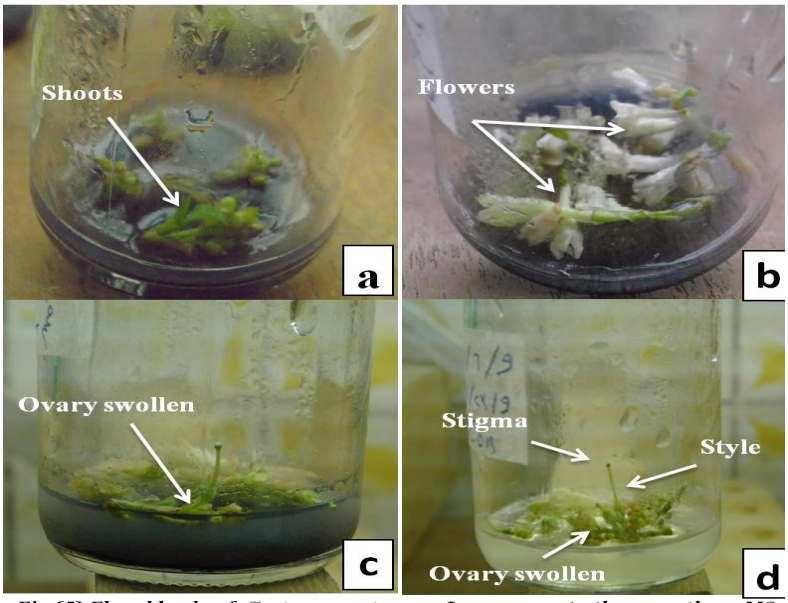

Fig (5):Floral buds of *Cestrum nocturnum* L response to the growth on MS medium:

A. Development newly setted to shoots after 4 weeks cultured
B. Development Initially flushed into flowers after 4 weeks cultured
C. Floral buds swollen after 4 weeks cultured.
D. Get swelling of Totally swollen and non flushed after 4 weeks cultured

3.3 Effect of cytokinin on shoot proliferation: Concerning to the effect of BA and Kin on the shoot multiplication of *Cestrum*. Data in Table (2) showed that MS medium supplemented with 0.5 mgl^{-1} BA + 2 mgl^{-1} Kin and 1 mgl^{-1} BA + 1.5 mgl^{-1} Kin obtained the highest number of shoot /explant (3.5) from node segments and shoot / explant (3) shoots from shoot tip (Fig 6 a) while the lowest number of shoots was produced on MS medium without plant growth regulators (2.2 shoot / shoot tips 2.4 shoot / node segments). The multiple shoot induction can be obtained from node segments and shoot tips when balance between BA and Kin,which is presened in the culture medium. Many authors reported that other ornamental plant species could be micropropagte on MS medium (Ferrira *et al*. 2009; Nakamura, 1991; Arshad et al. 2005 and Puchooa, 2004). These findings also support that herbaceous and semi-woody species respond better to MS medium supplemented with BA and Kin than to MS medium containing cytokinin alone. To obtain plantlets with uniform characteristics that are with clonal fidelity in terms of growth characteristics and habits, the direct regeneration is essential. It is useful means of producing plantlets form young and mature trees with a lower risk of genetic instabilities than the other routes of plantlets regeneration (Rao and Lee, 1986).

In general, MS medium supplemented with 1 mgl^{-1} BA and 1.5 mgl^{-1} Kin obtained the highest number of leave/ explant (6.50) leaves from node segments and (5.10) leaves from shoot tips (Fig 6). The lowest number of leaves was produced from the shoot tips **(3.90**) on MS medium without plant growth regulators. These findings are agreement with (Song *et al*. 1989; Berger and Schaffner , 1995) and (Atta – Alla *et al*. 2003)whom obtain the highest number of shoot and leaves induction frequency by culturing the explants of *Poulownia ssp, Swartzia madgascariesis and Bombax malabaricum and Callistemon lanceolatus* on MS medium, respectively.

Dealing with effect of BA and Kin on the shoot length of *Cestrum*, treatment with MS medium containing 1 mgl^{-1} BA+1.5 mgl^{-1} Kin significantly produced the tallest shoots of proliferation shoots (3.37) cm from node segments and (3.35) cm from shoot tips compared with control treatment and anther treatment. Increasing the concentration of BA and Kin decreased the number of shoots as well as shoot length . However, the length of proliferation shoots was decreased by increasing the concentration of BA and Kin in the culture medium. The results are in accordance to (Datta *et al*. 2007) which reported that increasing the concentrations of BA and Kin decreased the shoot length of *Jatropha curcas* L.

Table (2):- Effect of BA + Kin on *in vitro* shoot characters from shoot tip and nodal explants of *Cestrum nocturnum* L. Data were recorded after 4 weeks in culture**.**

Growth regulator mgl^{-1}	No. of shoot per culture		No. of Leaves per culture		average Length of Shoots (cm)	
BA+Kin	Shoot tip	Node segment	Shoot tip	Node segment	Shoot tip	Node segment
0.0+0.0	2.20c	2.40bc	3.90a	4.10a	1.85c	1.75c
0.5+2.0	2.90a-c	3.50a	4.10a	5.90a	2.27c	2.12c
1.0+1.5	3.00a-c	3.20ab	5.10a	6.50a	3.35a	3.37a
1.5+1.0	2.50bc	3.00a-c	4.60a	5.80a	3.03ab	3.15a
2.0+0.5	2.40bc	2.50bc	4.80a	6.30a	2.43bc	2.33c

* Means followed by the same letter within a column do not differ significantly (α=0.05) according to Duncan's Multiple Range Test (Duncan ,1955).

3.4. Effect of auxins on shoot rooting: The shoots more than (1.5 cm) transferred to the rooting stage and cultured on ½ strength of MS medium supplemented with different concentration of NAA and IAA alone for adventitious root induction (Table 3). rooting Percent and number of roots per shoot were remarkably activated by the auxin type and concentrations of auxins. Among two types of NAA was found to be comparatively more effective than other IAA at different concentrations tested for producing roots. On the MS medium with 0.5 mgl^{-1} NAA the explant produced the highest number of root per explants (Fig 6 b). The rooting frequencies were 100% for NAA and 70% for IAA. However, The

highest number of roots per explant (5.80) was achieved while using 0.5 mg/l NAA which was significantly higher than the other treatments. While the maximum length of the root was (7.5) cm when cultured on MS medium supplemented with 0.5 mgl^{-1} NAA and (4.75) cm when cultured on MS medium supplemented with 0.5 mgl^{-1} IAA suppled. Similar results were obtained by (Shah *et al*. 2006) how induced roots on *Bougainivillea spectabilis* on MS medium containing IBA or NAA at 2 mgl^{-1}, while root formation on MS medium without auxin was reported by (Kassab bashi and Kassab bashi, 2006) on *Dianthus caryophyllus*.

The rooted plantlets of *Cestrum* were carefully removed from rooting medium, transferred to greenhouse in small plastic pots with medium consisting of peat moss and sand (1:1 by volume). The plants were finally hardened by gradually reducing the humidity. After 4 weeks from transplanting the survival percentage reached (100%) plant. The plant grew well and normally as shown in. These results demonstrate that *Cestrum* can be propagated by micropropagtion using explants taken from *in vitro* mature shrubs. This facilitate the propagation of selected clones and thus led to better production and method of these shrubs.

Table (3):- Effect of different auxins types and their concentrations on promoting root formation from the *in vitro* grown micro-cutting of *Cestrum nocturnum* L. cultured on half salt strength MS medium. Data were recorded after 4 week of culture.*

Growth regulator mg l^{-1}		rooting %	No. of root/shoot	Length of root (cm)
Control	0.0	50.0b	2.30d	3.68c
NAA	0.25	70.0ab	4.30bc	6.64ab
	0.5	100.0a	5.80a	7.5a
	1	90.0ab	5.50ab	7.14a
IAA	0.25	50.0b	3.20cd	4.25c
	0.5	70.0ab	3.70c	4.75bc
	1	60.0ab	2.10d	3.44c

* Means followed by the same letter within a column do not differ significantly (α=0.05) according to Duncan's Multiple Range Test (Duncan ,1955).

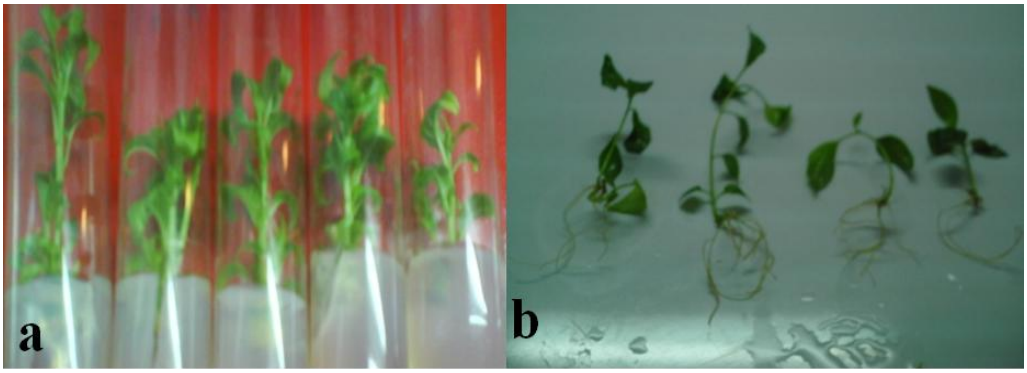

Fig (6):a) Multiplication of shoot on MS medium supplemented with 0.5 mgl^{-1}BA+2 mgl^{-1}Kin after 6-8 weeks.b) Development of root on ½ MS medium supplemented with 0.5 mgl^{-1} NAA

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تأثير موعد اخذ الجزء النباتي وبعض منظمات النمو في إكثار نبات الشبو الشجيري *Cestrum nocturnum L* بالزراعة النسيجية

الخلاصة

أجريت هذه الدراسة في مختبر زراعة الأنسجة بغرض إكثار الشبو الشجيري باستخدام زراعة الأنسجة في تجربة إحداث التضاعف للأفرع ، حيث استخدمت الأفرع الخضرية على (أطرف الأفرع والعقد المفردة) وكذلك أخذت الأفرع الزهرية الحاوية على براعم في مراحل نمو مختلفة (البراعم العاقدة جزئيا، براعم منتفخة جزئيا، براعم منتفخة كليا غير متفتحة والبراعم البادئة التفتح) المأخوذة من نبات الأم والتي زرعت على وسط MS (موراشيك وسكوج ، 1962) لتنفيذ تجربة المواعيد. حيث أظهرت النتائج بان أفضل موعد لأخذ الأجزاء النباتية كانت في شهر آب وشهر آذار لقابلية الأجزاء النباتية على البقاء بعد المعاملة. أعلى نسبة استجابة للأفرع كانت من أطراف الأفرع والعقد المفردة بلغت (82.33% و 95%) المأخوذة في شهر آب على التوالي. أما أفضل معدل لعدد الأفرع بلغ 2 فرع من أطراف الأفرع و 2.76 فرع من العقد المفردة في شهر آذار، كذلك النتائج أظهرت بان أفضل استطالة للكل من أطراف الأفرع والعقد المفردة كانت في شهر آذار وآب وبلغت (2.23 و 2.03) سم و (2.50 و 2.40) سم على التوالي. بالنسبة للبراعم الزهرية المأخوذة في مواعيد مختلفة (بالأيام) المزروعة على وسط MS الحاوي على (0.01 ملغم / لتر IBA و 250 ملغم/ لتر الكلوتامين) لمدة أسبوعين وكانت أفضل النتائج هو استجابة البراعم المنتفخة جزئيا بلغ 60 % و 85% للبراعم البادئة التفتح والتي تطورت إلى إزهار. نقلت النبيتات المتكونة من المرحلة السابقة إلى مرحلة التضاعف و زرعت النبيتات على وسط MS الحاوي على تراكيز مختلفة من الـ BA متداخلا مع تراكيز مختلفة من الKin لإنتاج أعلى معدل من الأفرع من القمم النامية والعقد المفردة الناتجة من نبيتات المرحلة السابقة حيث بلغ معدل عدد الأفرع 3.5 فرع من العقد المفردة و 3 فرع من أطراف الأفرع المزروعة على وسط MS الحاوي على 1 ملغم / لتر BA+ 1.5 ملغم / لتر Kin وعلى نفس الوسط تم الحصول على أعلى معدل لعدد الأوراق بلغ 6.50 ورقة من العقد المفردة و 5.10 ورقة من أطراف الأفرع . بعد وصول النيبتات إلى طول مناسب نقلت إلى مرحلة التجذير وزرعت النبيتات على وسط MS بنصف قوة أملاحه والحاوي على تراكيز مختلفة من NAA و IAA لوحده حيث أظهرت النتائج إن التراكيز المنخفضة من NAAو IAA أعطت أفضل زيادة لمعدل عدد الجذور وأفضل استطالة للجذور بلغ (5.8 جذر / جزء نباتي و 7.5 سم)و (3.7 جذر / جزء نباتي و 4.7 سم) على التوالي. بعدها نقلت النبيتات الناتجة من مرحلة التجذير إلى مرحلة الأقلمة بزراعتها في سنادين حاوية على البيتموس والرمل (1:1 حجم) حيث بلغ نسبة البقاء 100% تحت ظروف البيت الزجاجي.

EFFECTIVE SELECTION CRITERIA FOR ASSESSING DROUGHT TOLERANCE IN CHICKPEA

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ABSTRACT

Ten chickpea genotypes were evaluated at two separate field experiments conducted during spring growing season 2011 under non-stress and stress conditions. Some drought tolerance indices such as tolerance index (TOL), mean productivity (MP), harmonic mean (HM), stress susceptibility index (SSI), geometric mean productivity (GMP), stress tolerance index (STI), yield index (YI), yield stability index (YSI) and modified stress tolerance index (k_1STI and k_2STI) were calculated based on seed yield under non-stress (Yp) and stress (Ys) conditions. In addition to laboratory experiment included the effect of three osmotic potentials (0, – 0.4, and – 0.8 MPa) on germination and early seedling growth of these genotypes. The aim of this study is to determine the best index and also identifying the best drought tolerance chickpea genotypes. Genotypic correlation, genetic components and heritability were calculated for seed yield and all indices, as well as path coefficient analysis and selection indices were carried out for some tolerance indices including seed yield. Significant differences among genotypes were observed for Yp, Ys and all other drought tolerance indices. High heritability and genetic advance were observed for Yp, Ys and most of drought tolerance indices. Yp and Ys was positively and significantly genetic correlated with GMP, HM, MP, STI, k1STI and K_2STI. Path coefficient analysis revealed that the same indices (YI, and K_1STI) exhibited positive direct effects on seed yield under non-stress and stress conditions. The most effective indices have relative efficiency up to 37.785% and 6.338% over the direct selection were obtained (TOL, K_1STI) and (Ys, K_2STI) under both non-stress and stress conditions, respectively. Regarding to laboratory experiment, the germination and seedling growth were significantly inhibited at higher osmotic potentials compared to control. Based on results of field and laboratory experiments, three genotypes were selected which are superior in most of drought tolerance indices and germination and early seedling growth under osmotic potential and can be recommended for cultivation in semi-arid areas or used in breeding programs in the future.

KEYWORDS*:* Chickpea, Drought tolerance indices, Germination, Selection.

INTRODUCTION

In semiarid regions of northern Iraq, dry farming is often practiced for chickpea production. In these areas, precipitation being low and irregular, water deficit becomes the most important limitation to yield. Chickpea (*Cicer arietinum* L.) is the only pulse crop which is sown in spring without irrigation and therefore breeding for drought tolerance is an important task and objective in these semiarid regions. On the other hand, good selection criteria are needed to identify drought tolerance genotypes. Levitt (1972) noted that drought tolerance can be defined as: the water stress necessary to produce a specific plastic strain. The choice of parameters used to quantify the level of stress and the intensity of strain are somewhat arbitrary. Drought tolerance or tolerance in native plant species is often defined as survival, but in crop species it must be defined in terms of productivity (Passioura, 1983). Drought stress is the second important constraint of yield in chickpea after diseases, while research efforts and success of breeding have a share of 10% and 5%, respectively. Breeding for tolerance to drought and high temperature stresses in chickpea is limited by the lack of adequate selection criteria for stress tolerance (Toker and Cagirgan, 1998).

Breeding for drought tolerance is complicated by the lack of fast, reproducible screening techniques and the inability to routinely create defined and repeatable water stress conditions when a large amount of genotypes can be evaluated efficiently (Ramirez and Kelly, 1998). Achieving a genetic increase in yield under these environments has been recognized to be a difficult challenge for plant breeders while progress in yield seed has been much higher in favorable environments (Richards *et al.,* 2002). Thus, drought indices which provide a measure of drought based on yield loss under drought conditions in comparison to normal conditions have been used for screening drought-tolerant genotypes (Mitra, 2001). Several indices have been utilized to evaluate genotypes for drought tolerance based on seed yield such as Geometric Mean Productivity (GMP), Mean Productivity

(MP), Stress Susceptibility Index (SSI), Stress Tolerance Index (STI), Superiority Measure (Pi), and Tolerance Index (TOL). According to Richards (1996) selection for yield automatically integrates all the known and unknown factors that contribute to drought tolerance. Toker and Cagirgan (1998) used these indices for evaluation of drought tolerance in chickpea genotypes and found that the seed yield of the lines when grown under the non-stress condition increased at a rate of 53% over stressed condition. The line, FLIP 92-154C, was determinate as the best tolerant line to drought stress environment under the field condition. Also, seed yield strongly correlated with mean productivity, tolerance to drought stress and drought susceptibility index in the stress environment. Sadiq e*t al.* (1994) reported that drought tolerance may be present as an unidentified component of stability in genotype performance and provide an adequate assurance for farmers against environmental fluctuations in water-stress areas. Among the stress tolerance indicators, a large value of TOL and SSI represent relatively more sensitivity to stress, thus a smaller value of TOL and SSI are favored. Selection based on these two indices favor genotypes with low yield under non-stress conditions and high yield under stress conditions (Golabadi *et al.,* 2006). Ramirez and Kelly (1998) reported that selection based on combination of GMP and SSI may be more efficient for improving drought tolerance in common bean. Khalili *et al.* (2004) showed that based on GMP and STI indices, corn hybrids with high yield in both stress and non-stress conditions can be selected.

On the other hand, the drought plays an important role in determining germination rate and seedling development. Mensah *et al*., (2006) reported that the drought affecting the uppermost soil layer in responsible for poor seedling establishment and affecting the uniformity of plant density with a decrease in plant growth and consequently in crop yield. Drought can be alleviated by using drought tolerant genotypes. Thus, identifying drought tolerant mechanism is essential for measuring stress tolerance in large breeding population. For this, the osmotic potential with PEG or NaCl are useful methods for plant breeders by proposing early testes (germination and seedling growth) for screening new genotypes for their tolerance to water stress. This test has been carried out by many researchers on various species as found by Kalefetoglu *et al*. (2009), Gurbuz *et al*. (2009) that water stress affected the germination and seedling development parameters in some chickpea genotypes. According to Yucel *et al*. (2010) some genotypes of chickpea showed more tolerant to drought stress than other genotypes at germination and early seedling growth using nine genotypes of chickpea and five water stress (0, - 0.2, - 0.4, - 0.6 and - 0.8 MPa).

This study was conducted to assess the selection criteria for identifying drought tolerance in chickpea genotypes, high-yielding genotypes in drought stress and non-stress conditions. In addition to evaluate the effect of osmotic potential on germination and early seedling growth to support the results of the field experiment and to select the suitable genotypes can be recommended for cultivation in the drought area of northern of Iraq.

MATERIALS AND METHODES

1-Field experiments: Two experiments was conducted during the spring growing season 2011 at the Research Field belong to Field Crops Department, College of Agriculture, Salahaddin University, Erbil, Kurdistan Region, Iraq which is located on 36^{o} 10' N Latitude, 43^{o} E longitude and 415m above sea level. The first experiment was conducted under rainfall (stress) conditions (315 mm) registered by meteorological station at the site of the study. The second experiment was conducted under rainfall and irrigation (non-stress) conditions in the same location. Ten chickpea genotypes (Table, 1) obtained from the Directorate of Agricultural Researches/ Ministry of Agriculture/Erbil included local cultivar as a check were planted as spring-sowing on 10^{th} February 2011 using Randomized Complete Block Design with four replicates in each of experiment. Each replication consists of 22 rows (including 2 extra rows as guard rows) of 2.5 m length, two rows for each genotype, 2.5 m long, with 30 cm row to row and 15 cm plant to plant distance. From mid February 2011 until the end of growing season only the non-stress experiment were irrigated five times at (20 March, 10, 20 April, 5 and 10 May 2011). In each irrigation time, 25 mm of water was applied, totaling 125 mm of irrigation water during the whole period. Weeds were manually eradicated whenever they were observed in the field. After harvest the seed yield was recorded for every experimental unit. Some drought

tolerance indices were calculated for every genotype using the corresponding non-stressed and stressed plots in each replication. The resulting data were analyzed as obtained from a Randomized Complete Block Design and Least Significant Difference Test was employed for the mean comparisons. Yield under drought stress (Ys) and yield under irrigated (non-stress) conditions (Yp) should be combined to describe adequately yield-based drought tolerance. The drought tolerance indices were calculated as follows:

Table (1):- Pedigree of chickpea lines used in the study.

No.	Pedigree
1	Ghab 4 (Reg. No. cv. 245, P1638616) [developed by ICARDA]
2	Ghab 5 (Reg. No. cv. 246, P1638617) [developed by ICARDA]
3	Flip 03-73c×00TH22/Flip98-15c×se 199TER85485
4	Flip 03-28c×98TH113/[(Flip93-46c×Flip93-98c)×s95171]×s96094
5	Flip 04-34c×00TH41/Flip98-132c×s99075
6	Flip 83
7	Flip 85
8	Flip 87-68c
9	Marrakesh cultivar
10	Local variety (Check)

1. Geometric Mean Productivity (GMP) (Fernandez, 1992): $GMP = (Yp \times Ys)^{0.5}$

2. Harmonic mean (HM) (Kristin *et al.*, 1997): $HM = \frac{2(Yp \times Ys)}{(Yp + Ys)}$

3. Mean Productivity (MP) (Rosielle and Hamblin, 1981): $GMP = Y_p + Y_s / 2$

4. Superiority Measure (Pi) (Lin and Binns, 1988):

$$P_i = \left[\sum_{j=1}^{n} (X_{ij} - M_j)^2 \right] \Big/ 2n$$

5. Stress Susceptibility Index (SSI) (Fischer and Maurer, 1978):

$SSI = \frac{1 - Ys/Yp}{SI}$, where: SI = Stress Intensity = $1 - \bar{Y}_s / \bar{Y}_p$

6. Tolarance Index (TOL) (Rosielle and Hamblin, 1981): $TOL = Y_p - Y_s$

7. Yield reduction ratio (Yr) (Golestani and Assad, 1998): $Yr = 1 - (Ys/Yp)$

8. Stress Tolerance Index (STI) (Fernandez, 1992): $STI = (Ys)(Yp) / (\bar{Y}p)^2$

9. Yield index (YI) (Gavuzzi *et al.*, 1997): $YI = Ys / \bar{Y}s$

10. Yield stability index (YSI) (Bouslama and Schapaugh, 1984): $YSI = Ys/Yp$

11. Modified stress tolerance index (MSTI) as reported by Farshadfar & Sutka, (2003):

$MSTI = kiSTI$, while $k1 = (Yp^2) / (\bar{Y}p^2)$ for non-stressed and $k2 = (Ys^2) / (\bar{Y}s^2)$ for stressed, where ki = correction coefficient. Yp = yield genotype in a non-stressed environment. Ys = yield of a genotype in drought stressed environment. $\bar{Y}_p$ = mean yield in non-stressed environment. $\bar{Y}_s$ = mean yield in drought stressed environment. n = number of environments. X_{ij} = seed yield of ith genotype at the jth environment, and Mj = seed yield of the genotype with maximum yield at jth environment.

Components of variance (phenotypic ($\pm^2 P$), genotypic ($\pm^2 G$), environment ($\pm^2 E$), Genotypic coefficient of variability (GCV %), heritability in the broad sense ($H^2_{B.S.}$), genetic correlation (rG), expected genetic advance (EGA) and the expected genetic advance for the mean ($EGA\%$) were estimated using the components of expected mean squares from analysis of variance and covariance between traits (Walter, 1975). Then path coefficients were estimated according to Dewey and Lu (1959), where seed yield per plant was kept as resultant variable (under stress and non- stress separately) and other contributing characters as causal variables. Then, Selection indices construction, depending on the traits that showed a direct effect on seed yield [under stress (Ys) and non- stress (Yp) separately] were run through other traits based on the results of path analysis, and set up a set of selection indices based on these individual traits, as well as all possible combinations among them, and the method which described by Smith

(1936) and Hazel (1943) were used for construction selection indices.

2- Laboratory experiment: In order to supporting the results of field experiments, the seeds of ten genotypes of chickpea were tested under laboratory conditions to study the effect of drought stress on germination and seedling characters. Factorial experiment in Completely Randomized Design was used in this experiment where factor (A) contained three osmotic potentials (0 MPa (a_1), -0.4 MPa (a_2), and -0.8 MPa (a_3), whereas factor (B) was represented by ten genotypes of chickpea (b_1-b_{10}). Subsequently, 30 treatment combinations were included in this investigation. Every treatment was replicated 4 times and each replicate contained 5 plastic disposable dishes each of 10 seeds. The seeds of each genotype were subjected to three osmotic potentials (0, – 0.4, and – 0.8 Mega Pascal's). Distilled water was used for the zero tension. Solutions of NaCL were used to generate moisture stress by Electric Conductivity Apparatus. Two filter papers were situated at the bottom of every germinating disposable dish, and then seeds were laid uniformly over Whatmann filter paper. Thereafter, seeds and filter papers were wetted with their corresponding osmotic solution and covered with filter paper and later on dishes were sealed by polyethylene sheets to avoid seed desiccations. Seeds were considered to be germinated with the emergence of the radical (longed 1 mm) (Yucel *et al*., 2010). The following measurements recorded on 8th day after sowing (ISTA, 1999). Germinated seeds were daily counted. Duration required for peak germination (days), and days for emergence commencements were counted. Germination percentage, germination energy percentage were calculated from dividing number of germinated seeds on total seeds and from yield of number of germinated seeds after three days from starting divided on the total seeds, respectively, (Ruan *et al.*, 2002). Root and shoot lengths (cm) were measured by a mini roller. Germination rate (seedling.d^{-1}) was calculated from the following formula (Carleton, 1968): GR = No. of seeds emerged at first count / days of first count + …+ No. of seeds emerged at final count / days of final count. Mean germination time (days) was calculated from the equation below: ($MGT = \Sigma nidi/N$); where, ni = number of germinated seeds on day i, d= rank order of day i (number of days counted from the beginning of germinated), and N=total number of germinated seeds. Finally, data were analyzed by SAS program, version, 9 and the means were compared using Least Significant Different Test.

RESULTS AND DISCUSSION

The analysis of variance showed highly significant differences for seed yield (Yp and Ys) and all drought tolerance indices (Table, 2), which indicated that genotypes were differed for genes controlling yield and drought tolerance indices. Seed yield under non-stress conditions were positive linearly correlated with seed yield under stress condition (Fig. 1), suggesting that high potential yield under optimal conditions was necessarily result in improved yield under stress conditions. Thus, indirect selection for a drought-prone environment based on the results of optimum conditions will be efficient; this means that chickpea with low yield potential was more productive under stress conditions. According to the mean values, Yp, Ys, GMP, HM, MP, Pi, SSI, TOL, Yr, STI, YI, YSI, k_1STI, and k_2STI were 12.21, 8.20, 10.00, 9.80, 10.18, 11.46, 0.980, 4.01, 0.318, 0.684, 1.001, 0.667, 0.759, and 0.786, respectively (Table, 3). Comparison of means showed that under non-stressed conditions genotypes 9, 2 and 1 with averages 15.88, 13.8 and 12.93, respectively and genotype 3 with average 9.90 g/plant have the maximum and the minimum seed yield per plant among genotypes. Also, under drought stress conditions genotype 1 with average 10.40 have the maximum seed yield and genotype 4 with average 6.25 g/plant have the minimum among the genotypes. Genotypes 9, 1 and 2 had the highest geometric performances mean (GMP), harmonic mean (HM) and mean production (MP) and genotypes 3, 4, and 5 had the least amount of these indices. Genotypes 3, 4, and 6 had the highest Superiority Measure (Pi). Genotypes 4 and 9 had the most amounts of SSI and TOL. These genotypes which have higher amounts of SSI and TOL shows the great changes of a seed yield in stress condition, while the genotypes which have less amount of these drought indices such as genotype 1 shows the less changes of a seed yield in stress condition; this result reflected positively on the value of yield reduction ratio (Y_r). Since, in this case the genotypes will have less yield decrease in stress condition compared to normal condition (Rosielle and Hamblin, 1981). Acosta and Adams (1991) suggested that the selection according to SSI is effective when the experiment condition is a dry condition.

Genotype 9 had the highest stress tolerance index (STI) and genotype 3 and 4 had the least amount of this drought index. Fernandez (1992) declared that STI index is able to separate the genotypes which have a high yield and are tolerated against drought stress. The highest YI and YSI indices were observed for genotype 1and YI for genotype 9. Genotype 9 showed the highest value in Modified stress tolerance index for non-stressed (k_1STI), while the genotype 1 showed the highest value in Modified stress tolerance index for stressed (k_2STI). It is depicted from these results that highest value of TOL, larger the yield reduction under stress conditions and higher the drought sensitivity. Reduce value of TOL showed more yield in stress than non-stressed conditions. The ranks of the genotypes for MP, HM, GMP and STI were almost identical (Richards, 1996, Ramirez & Kelly, 1998, 2001 and Anwar *et al*., 2011).

Table (2) :-Mean squares of Yp, Ys and different drought tolerance indices in chickpea.

Drought tolerance indices	C. V.%	Mean squares			F. Value
		Replication (df = 3)	Genotypes (df = 9)	Error (df = 27)	
Yield in non-stressed (Yp)	7.203	3.626	12.177	0.773	15.76**
Yield in stressed (Ys)	8.631	2.327	7.936	0.501	15.85**
Geometric mean productivity (GMP)	9.612	0.935	9.541	0.924	10.33**
Harmonic mean (HM)	9.143	0.429	12.044	0.805	14.96**
Mean productivity (MP)	6.636	1.607	9.687	0.463	21.58**
Superiority Measure (Pi)	13.445	5.399	137.211	2.373	57.83**
Stress susceptibility index (SSI)	14.552	0.034	0.145	0.020	7.11**
Tolerance index (TOL)	12.729	0.649	2.785	0.255	10.83**
Yield reduction ratio (Yr)	17.097	0.001	0.018	0.003	6.03**
Stress tolerance index (STI)	10.990	0.174	0.028	0.006	30.77**
Yield index (YI)	12.886	0.057	0.130	0.017	7.83**
Yield stability index (YSI)	10.345	0.007	0.022	0.005	4.55**
Modified stress tolerance index for non-stressed (k_1STI)	13.574	0.058	0.512	0.011	48.31**
Modified stress tolerance index for stressed (k_2STI)	26.545	0.075	0.812	0.044	18.65**

** = Significant at 0.01 probability level.

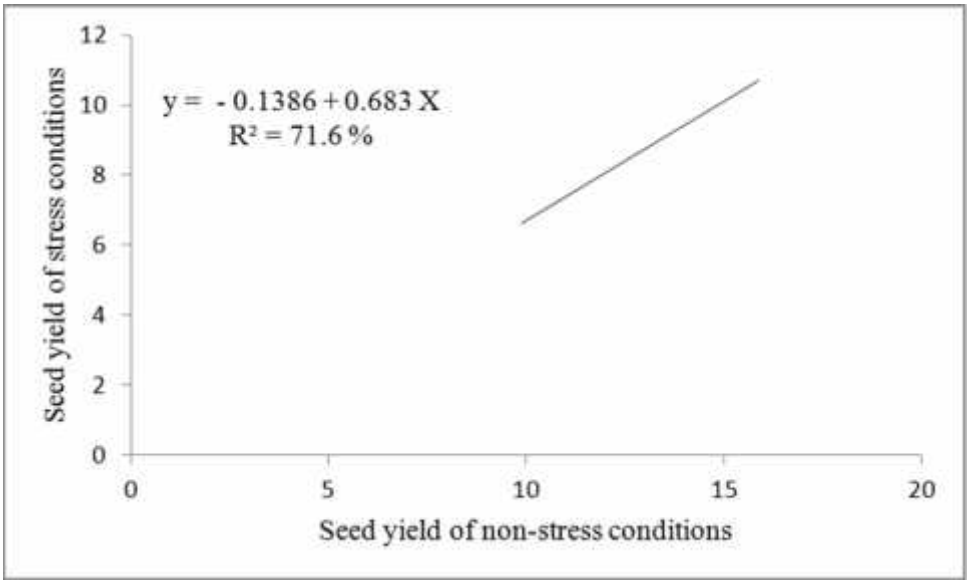

Fig. (1):- Relationship between seed yield of non-stress and stressed chickpea genotypes.

Table (3):- Mean of Yp, Ys and different drought tolerance indices in chickpea.

	Yp	Ys	GMP	HM	MP	Pi	SSI	TOL	Yr	STI	YI	YSI	k_1S	k_2STI
1	12.93	10.40	11.60	11.53	11.67	4.67	0.549	2.53	0.196	0.902	1.268	0.818	1.043	1.606
2	13.8	9.50	11.45	11.25	11.65	5.77	0.929	4.30	0.312	0.879	1.160	0.624	1.224	1.351
3	9.90	6.78	8.19	8.05	8.34	20.37	1.036	3.12	0.315	0.450	0.827	0.658	0.374	0.302
4	10.73	6.25	8.19	8.00	8.49	17.79	1.287	4.48	0.418	0.450	0.762	0.575	0.365	0.294
5	11.45	7.50	9.27	9.06	9.48	13.28	0.991	3.95	0.327	0.576	0.914	0.673	0.603	0.592
6	10.58	6.70	8.42	8.20	8.64	18.42	1.039	3.88	0.345	0.476	0.817	0.657	0.358	0.330
7	12.25	8.35	10.11	9.93	10.30	9.64	0.895	3.90	0.271	0.686	1.018	0.705	0.702	0.828
8	12.53	8.18	10.12	9.90	10.35	10.18	0.988	4.35	0.318	0.688	0.998	0.674	0.783	0.673
9	15.88	9.83	12.49	12.14	12.58	4.29	1.146	6.05	0.381	1.047	1.199	0.564	1.362	1.105
10	12.03	8.50	10.11	9.96	10.27	10.10	0.944	3.53	0.293	0.686	1.037	0.724	0.773	0.768
Mean	12.21	8.20	10.00	9.80	10.18	11.46	0.980	4.01	0.318	0.684	1.001	0.667	0.759	0.786
$LSD_{0.01}$	1.72	1.39	1.88	1.76	1.33	3.02	0.876	0.99	0.107	0.152	0.255	0.139	0.206	0.411

Components of variance (phenotypic ($\pm^2 P$), genotypic ($\pm^2 G$), environment ($\pm^2 E$), Genotypic coefficient of variability (GCV %), heritability in the broad sense ($H^2_{B.S.}$), expected genetic advance (EGA) and the expected genetic advance for the mean ($EGA\%$) illustrated in Table (4). Genotypic coefficient of variability (GCV %), broad sense heritability ($H^2_{B.S.}$), genetic advance as percentage of mean (GA %) were high for Yp, Ys and all drought tolerance indices except the ($H^2_{B.S.}$) for YSI. Hence substantial improvement in these indices may be achieved through selection under drought stress conditions. Improvement of these traits that have greater heritability, through direct selection, could be limited to the genotypes used in this study. The Superiority Measure (Pi) indicated high heritability in connection with genotypic variation. In this case, crop improvement, in terms of these traits, could be possible by simple selection because high heritability coupled with high genotypic variation revealed the presence of an additive gene effect (Noor *et al*., 2003).

Table (4):- Phenotypic variation and genetic parameters for Yp, Ys and different drought tolerance indices in chickpea.

	Yp	Ys	GMP	HM	MP	Pi	SSI	TOL	Yr	STI	YI	YSI	k1STI	k2STI
$\pm^2 G$	2.85	1.86	2.15	2.82	2.38	33.71	0.03	0.63	0.001	0.04	0.03	0.002	0.13	0.19
$\pm^2 E$	0.77	0.50	0.92	0.81	0.46	2.37	0.02	0.25	0.001	0.01	0.02	0.001	0.01	0.04
$\pm^2 P$	3.62	2.36	3.08	3.63	2.84	36.08	0.05	0.88	0.002	0.05	0.05	0.01	0.14	0.24
$\pm^2 G$	13.83	16.63	14.68	17.10	15.05	50.68	17.98	19.95	19.18	27.67	16.84	9.75	46.69	55.76
$H^2_{B.S.}$	78.67	78.78	69.98	77.72	83.73	93.42	60.42	71.07	55.72	78.96	63.06	47.04	92.20	81.25
EGA	2.636	2.130	2.161	2.605	2.485	9.877	0.241	1.174	0.08	0.03	0.236	0.079	0.599	0.697
$EGA\%$	21.60	25.98	21.61	26.53	24.24	86.21	24.60	29.61	25.20	43.28	23.53	11.77	78.90	88.61

To determine the most desirable drought tolerance criteria, the genotypic correlation coefficient (rG) between Yp, Ys and other drought tolerance indices were calculated (Table, 5). The yield under non-stress conditions (Yp) has a positive and significant genetic correlation with the yield under stress conditions (Ys) indicating that high yield potential under best possible conditions was anticipate superior yield under stress conditions. Therefore, indirect selection for stresses condition based on the performance of non-stressed conditions would be effective. Seed yield under non-stressed conditions (Yp) was positively and significantly correlated with GMP, HM, MP, STI, YI, k_1STI and k_2STI similarly, positive and significant association has also been observed among seed yield under stress condition (Ys) and GMP, HM, MP, STI, YI, k_1STI and k_2STI. These results were in accordance with those reported by Fernandez (1992) in mung bean. In stress condition, seed yield showed negative association with Yr, Pi and SSI. Therefore, these indices are suitable factors to identify chickpea genotypes with low yield and tolerant to drought because under stress yield decreased with increasing SSI (Anwar *et al.,* 2011). Mean productivity (MP) was significantly and positively correlated with HM, GMP, STI, YI, k_1STI and k_2STI (Link *et al*., 1999). Similarly, HM also had positive and significant genotypic correlation with GMP, STI, YI, k_1STI and k_2STI.

SSI showed significant and negative correlation with YSI and weak negative association with GMP, STI, and k_1STI. These are in agreement with the results of Link *et al*. (1999) and Anwar *et al*. (2011) in broad bean and chickpea, respectively. The positive correlation between TOL and non-stress yield (Yp) and the negative correlation between TOL and yield under stress (Ys) suggest that selection based on TOL will result in reduced yield under non-stressed conditions. Similar results were reported by Sio-Se Mardeh *et al*. (2006). SSI showed a negative correlation with yield under stress (Table 4). SSI has been widely used by researchers to identify sensitive and tolerant genotypes Sio-Se Mardeh *et al*. (2006). While Fernandez *et al*. (1992) proposed STI which discriminates genotypes with high yield and stress tolerance potentials. In this study, a linear model regression of seed yield under stress condition on STI revealed a positive correlation between this criteria with a similar coefficient of determination (R^2= 91.8%) (Fig. 2).

Table (5):- Genetic correlation coefficients between drought tolerance indices in chickpea.

	k_2STI	**k_1STI**	**YSI**	**YI**	**STI**	**Yr**	**TOL**	**SSI**	**Pi**	**MP**	**HM**	**GMP**	**Ys**
Yp	.803**	.989**	-.172	.895**	.986**	-.159	.523**	-.169	-.919**	.998**	.991**	1**	.882**
Ys	1**	.970**	.372	1**	1**	-.660**	-.020	-.655**	-.990**	.984**	.983**	1**	
GMP	.960**	1**	.106	1**	1**	-.445*	.258	-.429*	-1**	1**	1**		
HM	.923**	1**	.079	.990**	1**	-.384	.269	-.398	-.982**	1**			
MP	.914**	1**0	.054	1**	1**	-.368	.313	-.370	-.978**				
Pi	-.957**	-.956**	-.270	-1**	-.969**	.555**	-.160	.538**					
SSI	-.762**	-.352	-.960**	-.644**	-.419	1**	.783**						
TOL	-.152	.317	-.955**	.005	.233	.826**							
Yr	-.713**	-.331	-.991**	-.647**	-.383								
STI	.926**	1**	.084	.988**									
YI	1**	.980**	.330										
YSI	.467*	.004											
k1STI	.912												

*, ** = Significant at 0.05 and 0.01probability level, respectively.

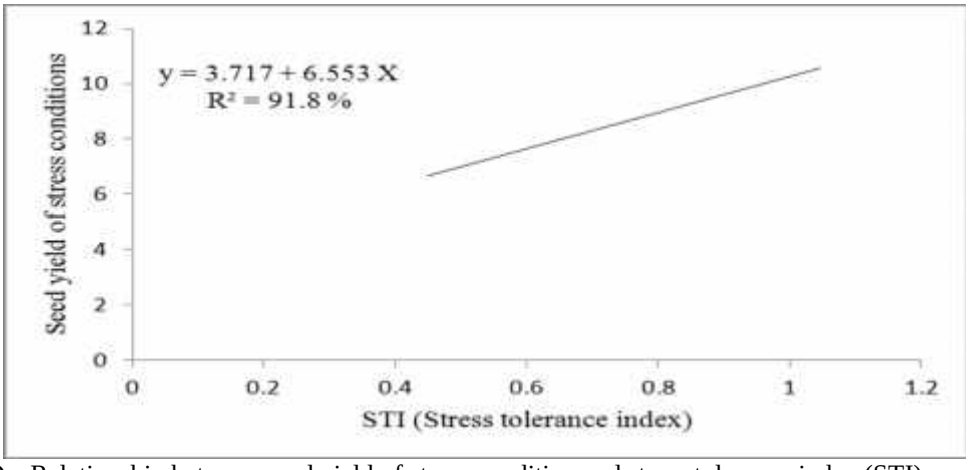

Fig. (2):- Relationship between seed yield of stress condition and stress tolerance index (STI).

Selection based on a combination of indices may provide a more useful criterion for improving drought tolerance of chickpea but study of genetic correlation coefficients are useful in finding the degree of overall linear association between any two attributes. Thus, a better approach than a correlation analysis such as path coefficient analysis is needed to identify

the most important traits of a direct effect on the seed yield to be adopted as a criterion for selection superior genotypes for both non-stress and stress conditions.

Under non-stress (Yp) as a dependent variable (Table, 6) revealed that the indices YI and K_1STI exhibited positive direct effects. Compared to the genetic correlation analysis; path analysis demonstrated that K_1STI exerted the highest direct effect on Yp. Although GMP and STI have high positive genetic correlation with Yp while direct effects on Yp per plant was negative. Conversely, SSI and YSI had a negative and small genetic correlation with Yp, but a great indirect effect via STI and SSI, respectively. So these traits can be directly used for selection under non-stressed condition and subjected for improvement of drought tolerance.

Table (6):- Direct and indirect influences of some drought tolerance indices on seed yield under non-stress (Yp) in chickpea.

	GMP	SSI	TOL	STI	YI	YSI	k_1STI	rG
GMP	***-5.766***	2.293	0.074	-16.091	4.702	-4.96	16.285	1**
SSI	2.474	***-5.344***	0.224	6.742	-3.029	4.496	-5.732	-0.169
TOL	-1.488	-4.184	***0.286***	-3.749	0.024	4.472	5.162	0.523**
STI	-5.766	2.239	0.067	***-16.091***	4.646	-0.393	16.285	0.986**
YI	-5.766	3.442	0.001	-15.898	***4.702***	-1.545	15.959	0.895**
YSI	-0.611	5.130	-0.273	-1.352	1.552	***-4.683***	0.065	-0.172
k_1STI	-5.766	1.881	0.091	-16.091	4.608	-0.019	***16.285***	0.989**

** = Significant at 0.01 probability level.

The path coefficient analysis based on seed yield under stress (Ys) as a dependent variable showed in Table (7). Direct effects exhibited by YI and K_1STI were positive, whereas all the other drought indices gave negative direct effects. K_1STI had the greatest positive on Ys (1.229) also; its indirect effects on Ys were positive through SSI and YI, but negative through GMP and YSI. The main reason for high direct effect of K_1STI was due to the high positive genetic correlation of this character with Ys. The second highest direct effect on Ys was of YI (0.753) also; its indirect effects on Ys were positive through K_1STI and SSI, but negative through GMP and YSI. It was observed that a higher indirect contribution was exhibited on Ys by most of the drought indices, such as the positive indirect of GMP through K_1STI; SSI and TOL through YSI; STI through YI; YI through K_1STI; YSI through SSI and TOL; thus, these traits related to Ys should be given emphasis in selection.

Table (7):- Direct and indirect influences of some drought tolerance indices on seed yield under stress (Ys) in chickpea.

	GMP	SSI	TOL	STI	YI	YSI	k_1STI	rG
GMP	***-0.731***	0.406	-0.182	-0.219	0.752	-0.205	1.180	1**
SSI	0.314	***-0.946***	-0.553	0.092	-0.485	1.859	-0.936	-0.655**
TOL	-0.189	-0.741	***-0.706***	-0.051	-0.004	1.849	-0.187	-0.020
STI	-0.731	0.396	-0.164	***-0.219***	0.744	-0.163	1.137	1**
YI	-0.731	0.609	-0.004	-0.216	***0.753***	-0.639	1.229	1**
YSI	-0.078	0.908	0.674	-0.018	0.248	***-1.936***	0.574	0.372
k_1STI	-0.702	0.721	0.107	-0.203	0.753	-0.904	***1.229***	1**

** = Significant at 0.01 probability level.

Selection indices under non-stress conditions revealed that the expected genetic advance in direct selection (100 %) for seed yield was 2.636 (Table, 8). The relative efficiency didn't reached up over the direct selection when the selection index included any one of these indices alone, while all selection indices reached up over the direct selection when the selection index included any two of these drought indices in addition to Yp except the selection index included TOL and YI which gave relative efficiency less than direct selection by 3.528%.

On the other hand the combination of any three traits didn't reached up over the direct selection except the index that included Yp, TOL and YI which reached up to 1.973% over the direct selection. The most effective indices have relative efficiency up to 37.785% over the direct selection and were obtained in the combination of two characters included TOL and K_1STI.

Table (8):- Evaluation of relative efficiency for many selection indices to predicting expected genetic advance in chickpea under non-stress conditions.

	Selection index		Genetic advance	Relative efficiency (%)
1	I= 0.787 X_1	X_1= Yp	2.636	100
2	I= 0.711 X_2	X_2= TOL	1.242	47.117
3	I= 0.631 X_3	X_3= YI	0.699	26.517
4	I= 0.922 X_4	X_4= K_1STI	1.298	49.241
5	I= 0.759 X_1 + 0.131X_2		2.643	100.266
6	I= 0.722 X_1 + 0.810 X_3		2.646	100.379
7	I= 0.248 X_1 + 3.097 X_4		2.802	106.297
8	I= 0.986 X_2 + 5.592 X_3		2.543	96.472
9	**I= 1.178 X_2 + 4.803 X_4**		**3.632**	**137.785**
10	I= –20.333 X_3 +15.833 X_4		3.367	127.731
11	I= 0.519 X_1 + 0.418 X_2 + 2.241 X_3		2.688	101.973
12	I= 1.780 X_1 –1.108 X_2 – 4.350 X_4		2.315	87.822
13	I= 3.428 X_1 + 35.656 X_3 – 31.586 X_4		0.386	14.643
14	I= 0.264X_2 + 3.690 X_3 + 0.918 X_4		2.261	85.774
15	I=1.352 X_1 – 0.596X_2 + 3.142 X_3 – 3.964 X_4		2.415	91.616

The determination of selection indices under stress conditions revealed that the expected genetic advance in direct selection (100 %) for seed yield was 2.130 (Table, 9). As is the case under non-stress conditions, the relative efficiency didn't reached up over the direct selection when the selection index included any one of these indices alone. The best relative efficiency up to 6.338% over the direct selection as in case of all character combinations as well as included two characters Ys and K_2STI.

Table (9):- Evaluation of relative efficiency for many selection indices to predicting expected genetic advance in chickpea under stress conditions.

	Selection index		Genetic advance	Relative efficiency (%)
1	I= 0.788X_1	X_1= Ys	2.130	100
2	I= 0.631X_2	X_2= YI	0.685	32.160
3	I= 0.813X_3	X_3= K_2STI	1.239	58.817
4	I= 0.750 X_1 + 0.300 X_2		2.130	100
5	**I= 0.375 X_1 + 1.574 X_3**		**2.265**	**106.338**
6	I= 0.861 X_2 + 0.318 X_3		1.114	52.300
7	I= 0.357 X_1 + 0.143 X_2 + 1.571 X_3		2.265	106.338

However, inclusion of more number of characters may create complications in the selection scheme. Hence, selection indices involving two drought indices would be more rewarding for enhancing the seed yield in chickpea under non-stress and stress conditions. Based on the both selection indices (I= 1.178 X_2 + 4.803 X_4) and (I= 0.375 X_1 + 1.574 X_3) which gave the highest relative efficiency in the expected genetic advance in seed yield under non-stress and stress conditions, respectively, and compensation X_2 and X_4 of the TOL and K_1STI, respectively, under non-stress conditions, as well as compensation X_1 and X_3 of the Ys and K_2STI, respectively, under stress conditions of the 10 varieties, we get the selection index values of these varieties which shown in the Table (10) under each environmental separately. Therefore we can select the varieties that gave the highest index value which are there 2 and 9 under non-stress and 1, 2, and 9 under stress conditions.

Table (10):- Values of efficient selection index for chickpea genotypes under non-stress conditions.

Genotypes	Selection index value under non-stress conditions.	Selection index value under stress conditions.
1	5.280	**5.506**
2	**10.921**	**5.689**
3	5.778	3.018
4	7.031	2.807
5	7.549	3.744
6	5.996	3.032
7	8.025	4.435
8	8.885	4.127
9	**13.080**	**5.426**
10	8.283	4.396

Regarding to the laboratory experiment; Table (11) shows the effect of osmotic potential levels, differences between chickpea genotypes and their interaction between on the germination and seedling growth. The results revealed that increased osmotic potential levels generally caused significant reduction in germination percentage, germination energy, germination rate, root length and shoot length, where an -0.8 MPa osmotic potential led to completely inhibition of the shoot growth, but mean germination time, days for peak germination and days for first germination increased at higher osmotic potential. Regression results analysis manifested that germination percentage, germination energy, germination rate, root length and shoot length were negative linearly correlated to varying osmotic potentials, except that of mean germination time, days for peak germination and days for first germination which were positive linearly correlated to varying osmotic potentials and they can be predicted by the equations (Table, 12). These results are in agreement with the observations of Kalefetoglu *et al.* (2009), Gurbuz *et al.* (2009) and Yucel *et al.* (2010). Among the ten genotypes the germination percentage ranged between 66.67 to 76.67%. Mean germination time 2.71 to 3.36. Earlier and rapid emergence was observed in genotype 9 which have maximum energy of emergence and germination energy. Maximum Germination rate (27.12 and 28.27 seedling/day) also recorded for genotypes 9 and 10, respectively, while minimum (23.381.52) in genotype 3. Least days for peak germination were recorded in genotypes 9 and 10 (3.33 day). Maximum value of root length and shoot length was obtained by the genotype 3 (5.30 and 2.58 cm), respectively. These results agree with Jasleen (2004) and Yucel *et al*. (2010) who also reported significant differences for these studied characters in different chickpea genotypes.

The results showed significant effect of interaction between genotypes and osmotic potentials in all characters. All cultivars completed germination percentage at control treatment in compare with little decrease at – 0.4 MPa osmotic potential, while, low germination percentage recorded at the – 0.8 MPa in most cultivars, where the genotypes 1 and 9 has been the best genotypes in this trait under – 0.8 MPa. Also, all genotypes showed little decrease in germination energy, germination rate, root length and shoot length at – 0.4 MPa compared with control, but more decrease at – 0.8, its noted that the shoot growth in all genotypes were stopped completely in – 0.8 MPa, as well as stop the growth of shoot of genotypes 5 and 6. These results agree with Yucel *et al*., (2010). On the other hand all genotypes showed little increase in mean germination time, days for peak germination and days for first germination at – 0.4 and – 0.8 MPa compared with control. On the basis of germination and seedling growth, we can conclude that the three genotypes 1, 9 and 10 are most resistant to drought compared to other genotypes. These results support the use of test germination and seedling growth by plant breeders in order to screening new genotypes for drought tolerance. In addition to, the results of laboratory experience also came in support of the results of field experiments.

Table (11):- Seed germination and seedling performances of ten chickpea genotypes under three osmotic potentials using NaCl concentrations.

Treatments		G (%)	MGT	GE (%)	GR	DPG	DFG	RL	SL
Osmotic potentials	0 MPa	100.00	2.64	90.63	37.83	3.51	2.00	10.70	5.13
	-0.4 MPa	93.00	2.95	88.25	32.67	3.43	2.03	2.07	1.69
	-0.8 MPa	21.13	3.39	8.88	6.57	4.70	3.25	0.16	0.00
LSD (0.05)		**1.71**	**0.11**	**2.03**	**0.73**	**0.25**	**0.32**	**0.19**	**0.12**
Genotypes	1	76.25	2.96	69.17	26.68	3.75	2.33	4.12	2.18
	2	71.67	3.05	60.83	24.08	4.08	2.50	4.72	2.56
	3	71.25	3.05	56.67	23.38	4.42	2.33	5.30	2.58
	4	73.33	2.98	59.58	26.65	4.50	2.33	4.49	2.21
	5	66.67	2.99	59.17	24.60	3.58	2.50	3.52	1.83
	6	66.67	3.36	58.33	24.07	3.96	2.50	3.59	2.01
	7	67.08	2.96	58.75	25.56	3.83	2.42	4.36	2.53
	8	69.58	2.71	63.33	26.49	4.00	2.67	4.76	2.58
	9	76.67	2.91	70.42	27.12	3.33	2.33	3.62	1.90
	10	74.58	2.94	69.58	28.27	3.33	2.33	4.63	2.36
LSD (0.05)		**3.11**	**0.20**	**3.71**	**1.33**	**0.46**	**N.S.**	**0.34**	**0.21**
0 MPa	1	100	2.73	100.00	36.34	3.00	2.00	9.57	4.45
	2	100	2.85	80.00	32.50	3.00	2.00	11.75	5.83
	3	100	2.83	85.00	35.27	4.00	2.00	13.75	6.08
	4	100	2.85	85.00	36.96	4.25	2.00	11.14	5.08
	5	100	2.58	90.00	38.58	4.25	2.00	8.93	4.03
	6	100	2.73	88.75	37.67	3.00	2.00	9.57	4.83
	7	100	2.50	90.00	40.59	4.13	2.00	11.44	5.78
	8	100	2.60	92.50	40.67	3.25	2.00	11.36	5.65
	9	100	2.59	97.50	37.92	3.25	2.00	8.04	4.00
	10	100	2.17	97.50	41.79	3.00	2.00	11.46	5.63
-0.4 MPa	1	100	2.80	96.25	34.54	3.75	2.00	2.43	2.08
	2	100	3.00	95.00	34.54	3.50	2.00	2.28	1.83
	3	91.25	3.05	77.50	28.02	4.25	2.00	2.02	1.70
	4	95.00	2.85	82.50	34.25	4.25	2.00	2.11	1.55
	5	87.50	2.93	85.00	30.17	3.00	2.00	1.64	1.45
	6	90.00	2.96	81.25	31.90	3.00	2.00	1.19	1.20
	7	87.50	2.92	83.75	32.98	3.00	2.00	1.47	1.80
	8	90.00	2.90	90.00	32.81	3.50	2.00	2.80	2.10
	9	96.25	3.14	96.25	33.73	3.00	2.00	2.51	1.70
	10	92.50	2.91	95.00	33.73	3.00	2.00	2.22	1.45
-0.8 MPa	1	28.75	3.34	11.25	9.18	4.50	3.00	0.35	0.00
	2	15.00	3.31	7.50	5.21	4.75	3.00	0.13	0.00
	3	22.50	3.28	7.50	6.85	4.75	3.00	0.12	0.00
	4	25.00	3.25	11.25	8.73	5.00	3.00	0.23	0.00
	5	12.50	3.48	2.50	5.04	4.75	3.50	0.00	0.00
	6	10.00	4.40	5.00	2.61	4.75	3.50	0.00	0.00
	7	13.75	3.45	2.50	3.13	5.25	3.25	0.18	0.00
	8	18.75	3.23	7.50	5.98	5.25	3.75	0.12	0.00
	9	33.75	3.08	17.50	9.71	4.00	3.00	0.30	0.00
	10	21.25	3.05	16.25	9.29	4.00	3.00	0.23	0.00
LSD (0.05)		**5.39**	**0.34**	**6.43**	**2.30**	**0.80**	**1.02**	**0.60**	**0.37**

Table (12):- Regression models showing the relationship between each germination performance and varying osmotic potential levels.

Character	Regression equation	R^2 (%)
G%	Y = 110.812 – 98.588 X	81.6
MGT	Y = 2.618 + 0.938 X	99.0
GE%	Y = 103.462 – 102.187 X	77.2
GR	Y = 41.32 – 39.075 X	87.0
DPG	Y = 3.285 + 1.488 X	70.0
DFG	Y = 1.802 + 1.563 X	76.8
RL	Y = 9.58 – 13.175 X	88.1
SL	Y = 4.838 – 6.413 X	96.3

R^2= Coefficient of determination; G%=germination percentage; MGT=mean germination time; GE%=germination energy; GR= germination rate; DPG=days to peak germination; DFG= days for germination; RL=root length; SL=shoot length.

In conclusion, based on our studies, it seemed that SSI were not useful indices to select for drought tolerant genotypes in plant breeding programs, because, SSI exhibited moderate heritability and Yr and YSI was less heritable than other indices usually not identifying genotypes with both high yield and drought tolerance characteristics. Therefore, K_1STI, YI, and TOL under non-stress conditions and K_1STI, YI, K_2STI and Ys under stress conditions seem to be useful yield-based drought tolerance indices to be employed in plant breeding programs for chickpea, which shows effective role in path analysis and selection index.On the other hand, although, drought stress reduced significantly the yield of all genotypes and some of them revealed tolerance to drought, which suggested the genetic variability for drought tolerance. Therefore, testing and selection under non-stress conditions may be the effective for increasing yield under stress conditions, where all genotypes showed higher yield under non-stress condition compared to stress condition, indicating the potential of genotypes to yield better if the favorable condition prevailed. This is supported by the positive relationship between seed yield under non-stress and stress conditions, in addition to that the same drought tolerance indices (YI and K_1STI)showed positive direct effect on seed yield under both conditions according path coefficient analysis. The significant and positive genetic correlation of Yp with Ys, K_1STI, K_2STI, YI, STI, TOL, MP, HM and GMP showed that these criteria indices were more effective in identifying high yielding cultivars under both conditions. Finally, we selected the genotypes 1, 2 and 9 that showed superiority in drought tolerance indices and characteristics of germination and seedling growth under osmotic potential as well as gave a high selection index value under non-stress and stress conditions which can be used in future breeding programs for improvement of drought tolerance.

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معايير الانتخاب الفعالة لتقييم تحمل الجفاف في الحمص

الخلاصة

نفذت تجربتين حقليتين منفصلتين، تحت ظروف عدم الشد الرطوبي والشد الرطوبي خلال ربيع الموسم 2011-2010 لتقييم عشرة تراكيب وراثية من الحمص. تم تقدير بعض مؤشرات تحمل الجفاف مثل دليل التحمل (TOL) ومتوسط الإنتاجية (MP) والوسط التوافقي (HM) ودليل التحسس للشد (SSI) والمتوسط الهندسي للانتاج (GMP) ودليل تحمل الشد (STI) ودليل الحاصل (YI) ودليل استقرارية الحاصل (YSI) وتعديل مؤشر تحمل الإجهاد (k1STI وk2STI) بناء على حاصل البذور تحت عدم الشد الرطوبي (YP) والشد الرطوبي (Ys). بالإضافة إلى تجربة مختبرية تضمنت تأثير ثلاثة جهود ازموزية (0 و - 0.4 و - 0.8 ميكا باسكال) على إنبات ونمو البادرات لهذه التراكيب الوراثية. الهدف من هذه الدراسة هو تحديد أفضل دليل وافضل التراكيب المتحملة للجفاف. تم تقدير الارتباط الوراثي والمكونات الوراثية والتوريث لحاصل البذور وأدلة الجفاف كافة، فضلا عن تحليل معامل المسار ودليل الانتخاب لبعض ادلة تحمل الجفاف بما في ذلك حاصل البذور. وقد لوحظت فروق معنوية بين التراكيب الوراثية فيYP وYs ومعظم معاييرتحمل الجفاف. لوحظ ارتفاع التوريث والتقدم الوراثي لYP و Ys ومعظم معاييرتحمل الجفاف. كان الارتباط الوراثي لـ YP وYs موجباً ومعنوياً مع GMP وHM وMP وSTI وK1STI وK2STI. بين تحليل معامل المسار أن المعايير(YI وK1STI) أظهرت تأثيراً مباشراً موجباً على حاصل البذور تحت ظروف عدم الشد الرطوبي والشد الرطوبي. كانت المعاييرالأكثر فعالية وذات كفاءة نسبية أفضل من الانتخاب المباشربمقدار 37.785٪ و 6.338٪ هي عند الانتخاب لـ (TOL، K1STI) و (Ys، K2STI) تحت ظروف عدم الشد الرطوبي والشد الرطوبي، على التوالي. وفيما يتعلق بالتجربة المختبرية، فانه يلاحظ تثبيط الانبات ونمو البادرات عند الجهد الأزموزي العالي مقارنة بمعاملة المقارنة. واستنادا إلى نتائج التجارب الحقلية والمختبرية، فقد تم انتخاب ثلاثة تراكيب وراثية متفوقة في معظم معايير تحمل الجفاف والإنبات ونمو البادرات والتي يمكن التوصية بزراعتها في المناطق شبه الجافة أو استخدامها في برامج التربية في المستقبل.

پیوەرێت هەڵبژاردنا ئەکتیڤ بو هەلسەنگاندنا خو لبەر گرتنا هیشکاتێی ل نوکا

یوختە

من دوو تێستێن زەڤیا ێین جوداھ ئەنجامدان ل سەقایەکێ نەبوونا خوناڤەکا زور و خوناڤەکا زور ل بهارا وەرزێ 2010-2011 بو هەلسەنگاندنا دەھ پێکهاتێین بو ماوەیی ل نوکا.هندەك ئاماژە هاتن پێڤانە کرن بو بەرگریا هشکە سالێی وەك رێبەرێ بەرگرێی (TOL) و تێکڕایا بەرهەمی (MP) و ناڤەندا تەوافوقی (HM) و رێبەرێ هەستیارێ زورێی (SSI) و تێکڕایا ئەندازیاری بو بەرهەمی (GMP)و رێبەرێ بەرگریا زۆر (STI) و رێبەرێ دەستڤە هاتی (YI) و رێبەرێ جێگیرێی دەستڤەهاتی (YSI) و زوریا خوناڤێ و گوڕینا نیشاندەرێ بەرگریا وەستیان (k1STIو k2STI) ب پشت گرێدان ب توڤی ل بن نەبونا خوناڤا زور (YP) و زوریا خوناڤێ (Ys)، سەرەڕای تێستا تاقیگەهی کو کاریگەریا هەرسێ ئەرکێن ئەزموزی (0 و - 0.4 و - 0.8 میگا باسکال) بو چاندن و مەزن بوونا شتلێن ڤان پێکهاتێن بوماوەیی، ئارمانجا ڤێ توێژنەوەێ دیارکرنا باشترین رێبەری و باشترین پێکهاتێن بەرگریا هشکە سالێی، تێکهەلیا بوماوەیی و پێکهاتەێین بوماوەیی و بوماوەیا دەستڤەهاتێین توڤی و بەلگێن هەمی هشکێی هاتن پێڤانە کرن، ژبلی شیکرنا کارگەهێن ئاراستەیی و هەلبژاردنا هندەم بەلگەێین بەرگری هشکێی ل وان ژی دەستهاتێی توڤی، من تێبینی کرن کو جوداهیەکا مەعنەوی یا هەی دناڤبەرا پێکهاتێین بوماوەیی ل YPو Ys و زوربەی پێوەرێن بەرگری کرنا هشکە سالێیی، بلند بوون و پێشکەفتنا بوماوەیی یا YPو Ys و زور پێوەرێن بەرگیا هشکە سالێی هات تێبینی کرن. پێکڤەگرێدانا بوماوەیی یا YP وYs پوزەتیڤ و مەعنەوی بوو دگەلGMP وHM و MP و STI وK1STI K2STI وHM و MP و STI و K1STI K2STI دەرکەفت شیکرنا کارگەهێن ئاراستە کو پیوەرێن (YI و K1STI) کارتێکرنەکا راستەوخو یا پوزەتیڤ هەبوو لسەر بەرهەمێ توڤی ل بن بارودوخێن نەبوونا خوناڤا زور و خوناڤا زور، پیوەر زور کاریگەر و توانستا رێژەیی باشتر بوون ل هەلبژاردنا راستەوخو ب بڕی 37.785٪ و 6.338٪ ل دەمێ هەلبژاردنێ بو (TOL، K1STI) و (Ys، K2STI) ل بن بارودخێ نەبوونا خوناڤا زور و خوناڤێ ل دویف ئێك. سەبارەت ب بە تێستا تاقیگەهی هات تێبینی کرن جێگیر بوونا شین بوون و مەزن بوونا شتلا ل ئەرکێ ئەزموزێی بلند بە بەراورد دگەل کارگەهێن بەراوردێ. و ب پشت گرێدان ب ئەنجامێن زەڤێی و تاقیگەهی، سێ پێکهاتێن بوماوەیی بلند ل زور بەراوردیا هاتن هەلبژاردن بو بەرگری کرنا هشکە سالێی و شین بوونا شتلا کو دکارین ئاماوژگاری کرن ب چاندنا وان ل دەڤەرێن نیمچە هشك یان بکارئینانا وان ل بەرنامێن پەروەردێ لە پاشەرۆژی.

HISTOMORPHOLOGICAL STUDY OF LUTEAL CELLS IN THE CORPUS LUTEUM OF CYCLIC AND PREGNANT COWS IN DUHOK PROVINCE

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ABSTRACT

This study conducted on forty six bovine corpora lutea were collected from local Duhok abattoir; among these samples thirty nine corpora lutea in various stages of estrous cycle and seven corpora lutea from pregnant genitalia. All corpora lutea were fixed with 10% neutral buffer formalin and stained with hematoxylin and eosin for microscopic examination to discover whether there is a difference between the luteal cells cyclic and pregnancy corpus luteum in cow. The results of this study showed that the cyclic corpus luteum had only two types of luteal cells. Large luteal cells were round in shape with pale staining cytoplasm with distinct boundary. The nuclei were centrally located, with prominent nucleoli and sparse chromatin network and the small luteal cells were indistinct boundary or irregular in outline with dark staining cytoplasm. They had dark compact nuclei eccentrically located with a condensed chromatin network. Corpus luteum of pregnancy were found with five types of luteal cells. Type 1 luteal cell, as a rounded cell, centrally located nucleus with one or two prominent nucleoli and these cells are less plump and regular in cell outline than type 2. Type 2 luteal cells were the largest cell, distinct nuclear membranes with one or two nucleus and one or two prominent nucleoli. Type 3 luteal cells, cell membranes and nuclear membranes that are shrunken. Type 4 luteal cells, spindle shaped appearance cell with intense staining of the cytoplasm. Type 5 luteal cells are the smallest luteal cells and had a small dense nucleus the cells had very little cytoplasm. These results showed that on the basis of structure there were substantial differences in the morphology of luteal cells between cyclic and pregnant cow.

KEYWORDS: Ovary, Corpus luteum, Luteal cells histomorphology, Cow.

INTRODUCTION

Corpus luteum is a key element in many reproductive processes including ovulation, length of the estrus cycle, recognition of pregnancy and embryo survival in all mammalian species (Milvae et al., 1996). Following ovulation the corpus luteum develop from the granulose cells of the graffian follicle and is maintained by luteinizing hormone (LH), Luteotropic or gonadotropic hormone of the anterior pituitary gland (Knight et al., 1988).The corpus luteum is a transient endocrine gland formed from the wall of the graffian follicle after the release of the egg, by a complex mechanism involving morphological and biochemical changes, it is a dynamic endocrine gland showing variation in size, structure and steriodogenic activities in different stage of the estrus cycle and pregnancy (Fields and Fields, 1996). The Corpus luteum consists of two types of luteal or steroidogenic cells, granulose (large) lutein cell and theca(small) lutein cells and several types of cells such as endothelial cells, pericytes, smooth muscle cells, macrophages, leucocytes and occasional plasma cells (Alila and Hansel,1984). The study was designed to determine the differences between the luteal cells in corpus luteum of cyclic and pregnant cows.

MATERIALS & METHODS

Ovaries of 46 cows were collected from a Duhok abattoir. The corpora lutea were classified to different groups according to stage of estrous cycle by gross examination depending on the size, color, consistency, protuberance and crossing to ovarian tissue (Okuda et al., 1988), as follows: twelve developing corpora lutea, nineteen fully developing corpora lutea and eight corpora lutea in regression. Seven corpora lutea of pregnancy were obtained after confirmation of a fetus in the uterus and the stage of pregnancy was determined by measuring of Crown- rumb length of fetus (Richardson, 1980), as follows: three corpora lutea of two month of pregnancy, two corpora lutea of fourth month of pregnancy, one corpus luteum of five month of pregnancy and one corpus luteum of six month of

pregnancy. The cyclic and pregnant corpora lutea were fixed in 10% neutral buffer formalin for histological study, routinely processed and embedded in paraffin wax. Sections at 5µm thickness were prepared and stained with hematoxylin and eosin (H&E) (Luna, L.G. 1968).

RESULTS

Two distinct luteal cell populations (large and small) were found during the different stages of cyclic corpus luteum. The large luteal cells were round or oval in shape with pale staining cytoplasm distinct boundary. The nuclei, which were usually centrally located, were large and vesicular; they were pale and had a sparse chromatin network. Prominent nucleoli were a feature of large luteal cells. The small luteal cells were indistinct boundary or had an irregular outline with dark staining cytoplasm. They had dark compact nuclei eccentrically located with a condensed chromatin network there was no appreciable difference in these features of luteal cell structure during different stages of cyclic corpus luteum in cow.

Whereas the luteal cells of corpus luteum of pregnancy were classified to five types.

Type 1 cells had round, centrally located vesicular nuclei with one or two prominent nucleoli. These cells are less plump and regular in cell outline than type 2 (Fig. 1).

Type 2 cells were the largest luteal cells distinct nuclear membranes with one or two nucleus and one or more prominent nucleoli (Fig. 2, 3).

Type 3 Luteal cells had cell membranes and nuclear membranes that are shrunken. The nucleus irregular in outline, coarsely granular and pale staining cytoplasm, in contrast with the vesicular nuclei of type 2 cells (Fig. 4).

Type 4 cells were easily identifiable by intense and diffuse staining of the cytoplasm, their spindle shaped appearance and hyper chromatic nuclei (Fig. 5).

Type 5 Luteal cells were the smallest luteal cells and had a small dense nucleus typical of advanced pycnosis. The cells had very little cytoplasm (Fig. 6).

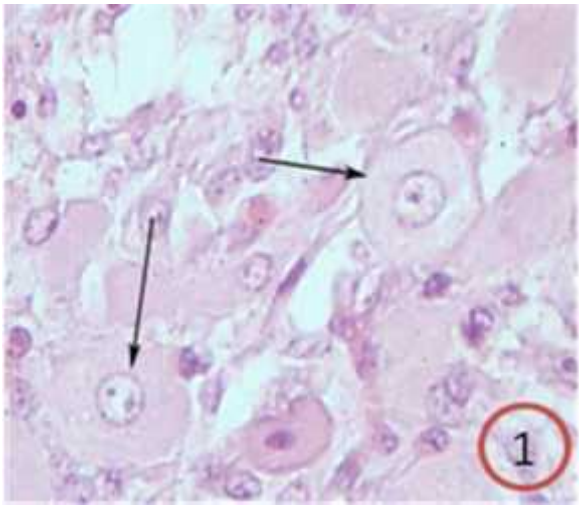

Fig. (1): Histological section of corpus luteum of pregnancy in cow showing Type 1 Luteal cells (H&E.400X).

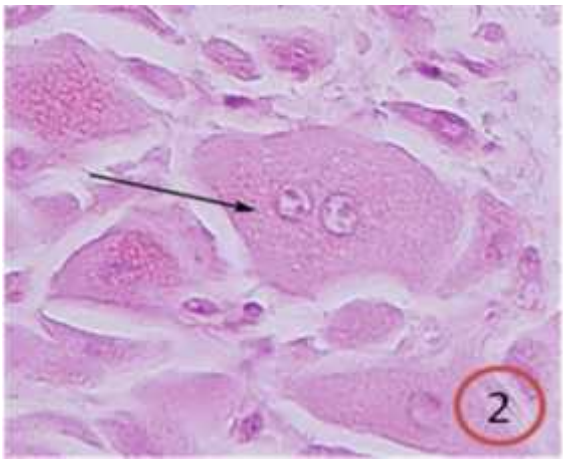

Fig. (2): Histological section of corpus luteum of pregnancy in cow showing Type 2 Luteal cells (H&E.400X).

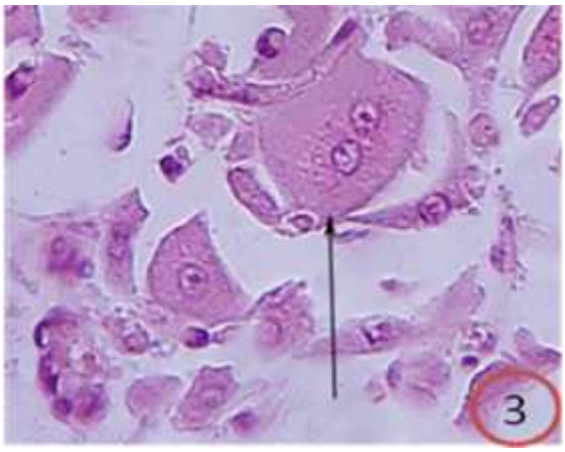

Fig. (3): Histological section of corpus luteum of pregnancy in cow showing Type 2 Luteal cells (H&E.400X).

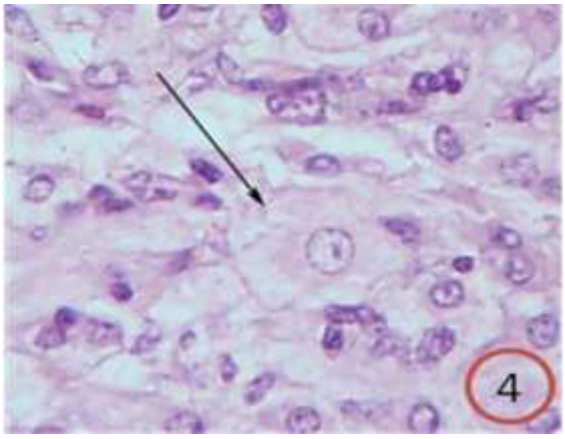

Fig. (4): Histological section of corpus luteum of pregnancy in cow showing Type 3 Luteal cells (H&E.400X).

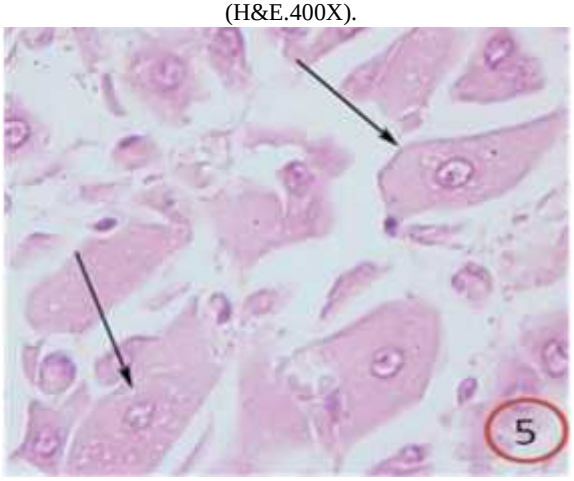

Fig. (5): Histological section of corpus luteum of pregnancy in cow showing Type 4 Luteal cells (H&E.400X).

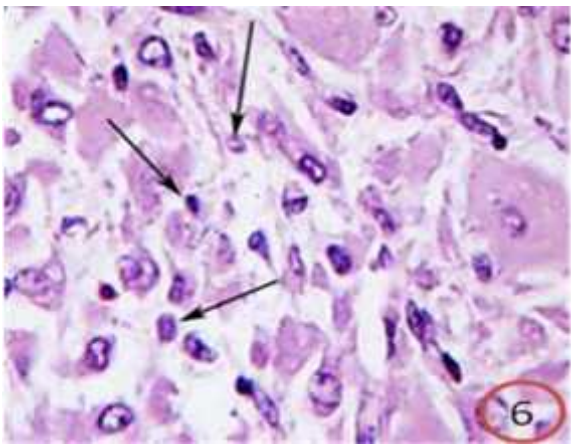

Fig. (6): Histological section of corpus luteum of pregnancy in cow showing Type 5 Luteal cells (H&E.400X).

DISCUSSIONS

In this study, morphology of luteal cells of cyclic corpus luteum during the different stage at light microscope was similar to that previously described in cattle (OŠhea, 1987; Oŝhea et al., 1989; Oŝhea et al., 1990; Fields et al., 1992; Wiltbank, 1994;) and sheep (Botha and Van Niekerk, 1980; Rodgers et al., 1984; Farin et al., 1989). Were two types of luteal cells found in the cyclic corpus luteum, large light staining cytoplasm distinct boundary. The nuclei, which were usually centrally located, and small dark staining cytoplasm cells, indistinct boundary and irregular outline. They had dark compact nuclei eccentrically located with a condensed chromatin network. From our result, the corpus luteum of pregnancy has five types of luteal cell, this result agreed with the result of (Okuda et al., 1988).The results agreed with finding of Sawyer, (1995) who found that the domestic ruminants corpus luteum consist of two subpopulation of steroidogenic cells commonly referred as small and large luteal cells. These cells differ not only in size and structural characteristic, but also in functional properties during pregnancy. Our results disagree with the result of Garcia Iglesias et al., (1992) who found that the luteal cells of non pregnant corpus luteum of cattle consist of five types of luteal cells, these cells developed from type one to type five, the first type is the principle inside the developing corpus luteum, the type two and three are in the mature corpus luteum and the two last types are in the degenerating corpus luteum. our results also disagreed with the result of Fields et al.,(1992) who concluded that the large steroidogenic luteal cells of the estrous cycle have morphological characteristic similar to those of large luteal cells during pregnancy, it's possible he examine the corpus luteum during the advance pregnancy because in the last two to three months of pregnancy the production of progesterone hormones for maintaining pregnancy don't depended on corpus luteum, but placenta contributed for production this hormones for maintaining pregnancy for this may be don't found any difference in luteal cells during estrous cycle and pregnancy.

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ڤەکولینەکا تەفنزانینا شێوەیی بو خانەیێن لوتینی یێن رەگەزێ زەر لدەمێ گەرا زایەندی و ئافسبونێ دا ل چێلا پارێزگەها دهوکێ

پوختە

ئەف ڤەکولینە هاتە کرن لسەر چل و شەش رەگەزێن زەر یێن چێلا هاتینە وەرگرتن لسەربراشخانا دهوکێ, دناف فان نمونادا سیە و نەھ رەگەزێن زەر یێن گەرا زایەندی بین و حەفت شوان یێن ئافسبونێ بین. هەمی ئەف رەگەزێن زەر کرنە دناف 10% نیوترال بەفەر فورمالین باشان هاتنە بویاغکرن ب بویاغا هیماتوکسلین و ئیوزین ژبو پشکنینکرنێ لبن میکروسکوپێ داکو بزانن ئەرێ جیاوازی هەیە ل خانەیێن لوتینی دناف بەرا دەمێ گەرا زایەندی و دەمێ ئاقسبونێدا ل چێلا. ئەنجام هاتنە دیتن کو رەگەزێ زەر یێن گەرا زایەندی پێك هاتیە ژ دوو جورێن خانێن لوتینی, خانێن لوتینێن مەزن کو شێوەی وان کروڤربین و سایتوبلازم کێم بویاغ وەرگردبی و سنورێت وان دیاربین کاکلکا وان دکەفتە نیفەکا خانێ و نافکوکەکا بەرجاف و تورا کروماتینی یا خلولەبی. بەلێ خانەیێن لوتینێن بچیك سنورێت وان نەت دیاربین ژدەرفە نەت رێك و پێك بین و سایتوبلازم تێر بویاغبین و کاکلکا وان دکەفتە تەنیشتا خانێ و تورا کروماتینی یا تژیبی. بەلێ ئەنجامێت مە هاتنە دیتن ل رەگەزێ زەر یێن ئافسبونێ پێك هاتیی ژ پێنج جورێن

خانێن لوتینی . خانەیا لوتینی جورێ ئێکێ ئەفە خانەیەکا کروڤربی و کاکلکا وێ دکەفتە نیڤەکا خانێ دگەل ئێك یان دوو نافکوکێت دیار ئەف خانەییێن هەنێ کێم دیتن وەك کوم کوم ئو دیوارێ دەرەکی پێب رێك و پێکڤبی ژ خانەییێن لوتینی جورێ دووێ. خانەییێن لوتینی جورێ دووێ ئەف خانەیە مەزنڤرین خانەبی و دیوارێ کاکلکا یێ دیاربو ئو ئەف خانە پێك هاتیی ژ ئێك یان دوو کاکلکا و هەر ئێك ژ وان پێك هاتیی ژ ئێك یان دوو نافکوکا. خانەییێن لوتینی جورێ سیێ دیوارێ خانێ و دیوارێ کاکلکێ پێت قورمچی بوون. خانەییێن لوتینی جورێ چارێ ئەف خانە دیاربوون کو شێوەی وان درێژوك بین و سایتوبلازمێ وان کەلەك بویاغ وەرکردبی. خانەییێن لوتینی جورێ پێنجێ ئەف خانە هاتنە هژمار بچیکڤرین خانێت لوتینی پێك هاتیی ژ کاکلکا بچیك ئو کێم سایتوبلازم . ئەف ئەنجامە بو مە دیار دکەن کو جیاوازیەکا مەزن یا هەی ل شێوێ خانەییێن لوتینی دناف بەرا زەگەزێن زەر لدەمێ گەرا زایەندی ئو دەمێ ئافسبونێ دا ل چێلا.

دراسة نسيجية شكلية للخلايا لوتينية في الاجسام الصفراء لدورة الشبقية والحوامل في الابقار محافظة دهوك

الخلاصة

أجريت هذه الدراسة على ستة و أربعون جسما" اصفرا" لابقار جمعت من مجزرة دهوك, من بين هذه عينات تسعة وثلاثون جسما" اصفرا" كانت في عدة مراحل للدورة الشبقية و سبعة جسما" اصفرا" كانت للعينات الحوامل, كل الأجسام صفراء ثبتت في 10% من فورمالين مخفف المتعادل وصبغت بصبغة هيماتوكسلين و أيوزين واخذت الى فحوصات النسيجية لاكتشاف اذا كان هنالك اختلاف في الخلايا اللوتينية للاجسام الصفراء لدورة الشبقية والحوامل في البقار. وأضهرت النتائج بان الاجسام الصفراء لدورة الشبقية كانت تحتوي على نوعين من الخلايا لوتينية, الخلايا اللوتينية الكبيرة كانت دائرية الشكل مع صبغة سايتوبلازم شاحبة و حدود الخلية واضحة والنواة تقع في منتصف الخلية مع النوية بارزة وشبكة الكروماتينية الخفيفة اما الخلايا اللوتينية الصغيرة كانت حدودها غير واضحة وغير منتظمة الشكل مع صبغة سايتوبلازم غامقة و النواة الغامقة جانبية الموقع وشبكة الكروماتينية المكثفة. الأجسام الصفراء للحوامل فوجدت خمس انواع الخلايا اللوتينية. النوع الاول من خلايا اللوتينية دائرية الشكل ونواتها مركزية الموقع مع واحد او اكثر نوية وهذه الخلايا اقل تجمعا" و حدودها اكثر منتضما" مقارنة مع الخلايا اللوتينية نوع الثاني. النوع الثاني من الخلايا اللوتينية يعتبر هذه الخلايا اكبر خلايا اللوتينية وواضحة غشاء نواتها وتحتوي على نواة واحدة أو اثنين واحتواء النواة على اكثر من نوية بارزة. النوع الثالث من خلايا اللوتينية غشاء الخلية وغشاء نواة تكون منكمشة الشكل. النوع الرابع من خلايا اللوتينية ظهورها مغزلية الشكل مع صبغة سايتوبلازم غامقة. النوع الخامس من الخلايا اللوتينية بأنها اصغر انواع خلايا اللوتينية واحتوئها على نواة صغيرة مكثفة وقليل من السايتوبلازم. من هذه النتائج يتبين على أساس التركيب بأن هنالك اختلاف كبير في الشكل للخلايا اللوتينية بين ألاجسام الصفراء للدورة الشبقية والحوامل في الابقار.

CLINICAL AND PATHOLOGICAL STUDIES OF LYMPHOID LEUKOSIS IN POULTRY

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ABSTRACT

A total 19 cases of clinically affected chickens with lymphoid leukosis from different flocks was recorded in this study. Only nine cases were diagnoses as a lympholid leukosis according to clinical sings, gross and histopathological changes. The disease were examined clinically prolong emaciations, weakness and death, post mortem changes show enlargement of both spleen and liver with different multifocal to focally extensive nodules appears as yellowish white to gray lesions. Microscopically show there is a diffuse infiltration of large (lymphoblast) and small lymphocytes in the liver and spleen, with hematoxylin and eosin staining. This study aimed to record the diagnosis of lymphoid leukosis based on case history, clinical sings, post mortem changes and histopathological features of affected organs.

KEY WORDS: Leukosis, Poultry, pathology studies

INTRODUCTION

Leukosis is one of the neoplastic or sarcoma disease in poultry caused by a virus of the leukosis belong to retrovirus called Avian lympholid Leukosis (ALL) (wang, et al. 2007) which may take the form of a tumor of the visceral organ and metastasis to other tissues of the chicken that causes enlargement and swelling of the abdomen and visceral organs (Merck., 2008, Regenmortel, et al. 2000). It's a very rare primary tumor in mammals characterized by high blood lymphocyte counts and the most common form of the avian leukosis complex of diseases caused by avian retroviruses (Tulman, et al. 2000, Mozisek., 2005) or viscera lymphamatosis recorded as one of three economically important viral induced lymphoproliferative disease of poultry. The other two are Merck disease and reticuloendotheliosis (Alaka, et al. 1999). Clinically ALL is usually affected birds are seen between the ages of 14 to 30 weeks and show nonspecific signs of emaciation, in appetence, dehydration, diarrhea, weakness and emaciation before death. The gross pathologic features of diagnostic significance are extensive swelling in different of visceral organ mainly liver and spleen (Merck., 2008). As well as multiple metastatic lesions occurs in most other visceral organs (Mathew, et al. 2010). Histopathologically there is extensive infiltration by tumor cells lymphoblasts with variable size small and large which distributed through out of different paranchymaotus organ especially liver and spleen. The current study was analyzing the diagnosis of lymphoid leukosis in poultry based upon clinical, grossly and histological characters of tumor cells.

MATERIAL AND METHODS

SAMPLE COLLECTION

A total 19 cases of adult hens affected clinically were obtained from several poultry flocks after close inspection of these cases taken for 3 months, these flocks was from different area, while ten apparently normal adult laying hens were bought from the local market which are used as a control group nine of death birds was examined under post-mortem examination after manifestation a clinically and the changes was recorded, organs which show lesions were determined and specimens was taking for histopathological study. Diagnosis of lymphoid leukosis was done according to clinical history, signs and symptoms, in addition gross and histopathological changes at the end of this study. Histopathology was done in

histopathology and molecular laboratory at Faculty of Veterinary Medicine, Duhok Research Center. For histopathological studies, morbid organs with typical lesions from several organs like liver, spleen, lung, and kidney were collected only and fixed in neutral buffered formalin saline solution10%. Tissues were then dehydrated in different concentration of ethanol, cleared in xylen, embedded in white paraffin wax at melting point 56-58C for preparation of paraffin block. Sections were made at 3-4 micrometers with leica microtome (leica, Germany) slides were stained with hematoxylin and eosin H and E staining according to (Luna., 1968).

RESULTS
CLINICAL SIGNS

The most observed clinical signs were recorded in affected chickens during inspection period of this study there was marked degrees of body weight with progressive emaciation of chickens above the 14 weeks, mild diarrhea, in appetence and enlargement of abdomen which continued until death of affected bird, the study was not show any obvious signs of paralysis

PATHOLOGICAL FINDINGS
MACROSCOPICAL APPERANCE

While there were no consistent macroscopic observations associated with lymphoid leukosis in the affected birds, pathological changes in the liver and spleen were most frequently observed in nine of affected birds. The livers and spleen has been observed hepatomegaly & splenomegaly with white or yellow in colour. Necropsy revealed the presence of different multi-nodular tumour masses lesions of varying sizes and locations were identified clearly in both liver and spleen which also appears yellowish white-to grey in colour as show in (Figure 1A and B), while in the lung and kidney lesions appears very small pin point white to yellow in color. Signs of paralysis and enlargement of the peripheral nerves were not seen in any of the affected birds examined in this study.

MICROSCOPICAL CHANGES

Histological sections studies of spleen showed the presence of solid sheets of a uniform population of lymphocytes small and large size (lymphoblasts) as show in (Figure 2A, B). The tumour cells had large vesicular nuclei with one or more prominent nucleoli and eosniophilic cytoplasm. Mitoses were common. Infiltration of the liver by neoplastic cells was recorded in all 9 cases and there was small normal area of hepatic cells present while tumor cells was occupied most parts of liver (Figure 3A and B). The structure of hepatocytes is loss and diffuses bile duct hyperplasia associated with extensive solid sheets of lymphocytes which effaced the normal architecture and filled all the gap of distructed area. The spleen, were also place which showed extensive infiltration by tumour cells which are different size like liver. Also there were very early small metastatic areas in the parenchyma of kidney as well as lung of affected bird destruction and proliferation of alveolar interstitial tissue as show in (Figure 4 and 5A and B)

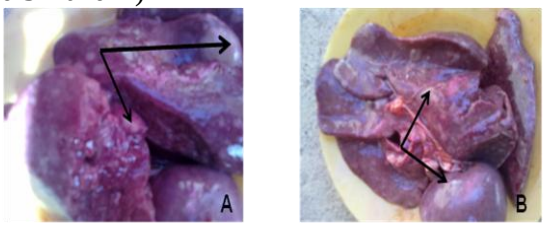

Figure 1 Enlargement of both liver (A) and spleen (B) and nodules variable size and yellowish white to gray in colure on the surface of the liver

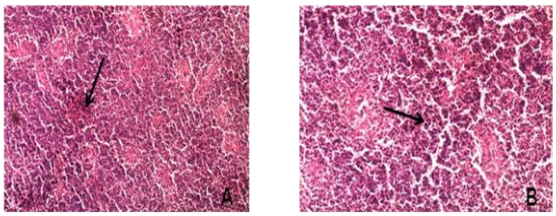

Figure 2: Histopathological changes of spleen which show diffuse infiltration of large and small lymphoblast distributed through out of both cortex and medulla (H & E; 10xA, 20xB)

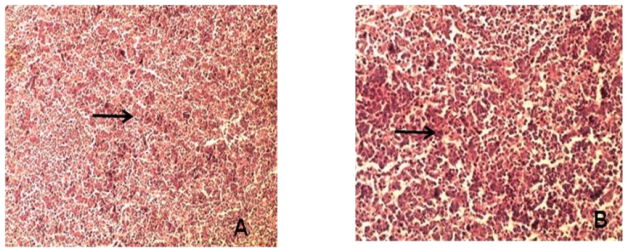

Figure 3 : Histopathologicla changes of liver which show diffuse infiltration of large and small lymphoblast which occupy all part of liver (H & E; 4 x A, 20xB)

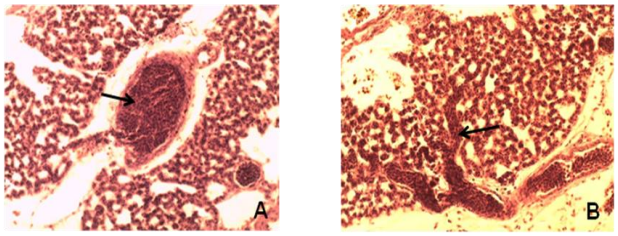

Figure 4: Histopathological changes of lung which show diffuse infiltration and aggregation of large and small lymphoblast as show in arrow in parenchyma, proliferation of interstitial alveolar space and distruction of alveoli wall (H & E:10x A, 20xB)

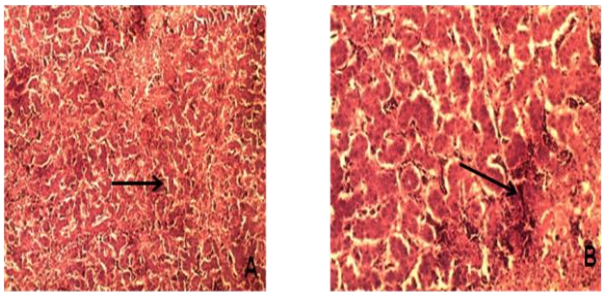

Figure 5 : Histopathological changes of kidney showing small foci of metastasis tumor cells in the parenchyma and interstitum of kidney (H & E; 10x A, 20xB)

DISCUSSION

The differential diagnosis of neoplastic disease in poultry is usually made on a number of factors which include age, clinical signs, incidence, pathological observations (Purchase and Burmester, 1978, Al-Sadi and Hussein 2010). In the cases we describe in our study, the diagnosis of lymphoid leukosis was based mainly on the pathological features both of macroscopically and microscopically beside of case history and clinical sings. However, clinical and pathological features of avian leukosis can be used to diagnose the disease as described by this study and other previously (Alaka, *et al.* 1999, Wang and Juan, 2002, Merck., 2008). Avian leukosis is grossly characterized by enlargement of the liver and spleen with histologically characterized by massive infiltration of lymphoid cells in visceral organs (Randall., 1991). The problems of diagnosis of neoplatic disease in chickens, the disease is grossly similar to other neoplastics disease such as Marek's disease and reticuloendotheliosis. However, histological appearance of avian leukosis differs from the other two diseases by absence of peripheral nerve lesions (neuropathic disease) (Merck., 2008) as well as according to (Randall.,1991) and (Merck., 2008), avian leukosis is characterized histologically by massive infiltration of lymphoid cells in visceral organs beside the lymphoid organs as a liver and spleen were consistently involved and this is of considerable diagnostic significance in lymphoid leukosis. This is what is seen grossly as the nodular grey spots on the surface of these organs which greatly agreements with other studies. The histological distribution of tumour cells in the liver was either diffuse or nodular whereas in Merck disease the distribution of tumour cells is perivascular. The tumour cells in these cases were uniformly lymphoblastic which is consistent with lymphoid leukosis. In Merck disease, the neoplastic cells are pleomorphic, including small, medium and large lymphocytes, lymphoblasts and reticulum cells (Beyer, et al. 1980). The current study demonstrates the avian leukosis and based on pathological findings it shows that the disease exists in our country. The viruses and synergistic effects with other diseases will be important for understanding the pathogenesis and management approach. It is equally important to screen local hatcheries for virus and strengthen of avian leucosis control and surveillance for imported chicks.

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ڤەکولینەکا کلینیکی و تەڤنزانینا نەخوشیا ل نەخوشیا لەمفوید لیکوسز ل مریشکا

پوختە

ئەف ڤەکولینە هاتە کرن ل سەر پشکنینا نوزدە مریشکا کو نەخوشبین ب نەخوشیا لەمفوید لیکوسز ئەفە ژ جەند پروژا وەرگرتن. ئێتنیّ نەھ مریشك هاتنە پشکنینکرن کو هەلگریّت ڤیّ نەخوشییّنە , هاتنە پشکنینکرن لسەر بنەماییّت گھورینیّت بەرجاف و تویکاری و تەڤنزانینا نەخوشیا. گھورینیّت بەرجاف پێکھاتیبی ژ حشکبونەکا بھیّز و لاوازبونیّ و پلشی مرن. گھورینیّت تویکاری پشتی مرنیّ پێکھاتیبی ژ مەزنبونا خالخالك و میّلاکا رەش دگەل چەند پرسکا لسەر ڤان ئەنداما کو رەنگیّوان سپی بو رساسی بین. ل پشکنینا تەڤنزانینا نەخوشیا لبن میکروسکوپیّ هاتە دیتن کو بەربلاڤبنا تەپکیّت مەزنیّت لەمفوبلاست ئو ھەر وەسا تەپکیت بچیکیّت لەمفوسلیت ل ئەندامیّ میّلاکا رەش و خالخاکیّ ئەفە پشتی هاتینە بویاغکرن ببویاغا هیماتوکسلین ئو ئیوزین. ئەف ڤەکولینا بومە دیاردکەت کو نەخوشیا لەمفوید لیکوسز دھیّتە پشکنینکرن لسەر بنەماییت گھورینیّت بەرجاف ئو توکاری پشتی مرنیّ ئو گھورینیّت تەڤنزانینا نەخوشیا بو ئەندامیّت

دراسة سريرية و مرضية **lymphoid leukosis** في الدواجن

الخلاصة

كان مجموع الحالات تسعة عشر من الدجاج المصاب سريريا بمرض lymphoid leukosis ومن مختلف الحقول. سجلت في هذه الدراسة فقط تسعة من الطيور تم تشخيصها بالاصابة بالمرض اعتماداً على الاعراض السريرية والصفة التشريحية والتغييرات المرضية النسجية. تميزت الطيور المصابة سريريا بالهزال المستمر والضعف العام ثم الموت. أظهرت التغيرات مابعد الموت بتضخم كل من الكبد والطحال مع وجود بور او افات موضعية على شكل عقيدات ذات لون ابيض مصفر الى رمادي منتشرة على سطح كل من الكبد والكلية. نسيجيا تميزت بوجود ارتشاح كثيف للخلايا اللمفاوية الصغيرة والكبيرة في الاعضاء المصابة وباستخدام صبغة الهيماتوكسلين والايوسين. هذه الدراسة اعتمدت على دراسة المرض من الناحية السريرية والعيانية اضافة الى التغيرات المرضية النسيجة.

TOTAL HEAVY METALS CONCENTRATIONS IN SURFACE SOILS OF SELECTED INDUSTRIAL SITES OF THE CITY OF ERBIL.

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ABSTRACT

Concentrations of heavy metals Cu, Zn, Cd, Pb, Ni, and As were determined in 19 surface soil samples collected from south and north industrial sites in the city of Erbil using atomic absorption spectroscopy. Soil pH, conductivity, cation exchange capacity and total organic matter were also measured. Heavy metals concentrations were determined after digesting the samples with aqua regia solution. The range of the heavy metals recorded in this study in µg/g were: Cu (6.66-7.89), Zn (1.42-2.78), Cd (0.52-0.78), Pb (23.55-24.70), Ni (631-687), and As (15.33-18.47). The reported results indicate that total heavy metal content of Ni and As were higher than the threshold limits set by the EPA and other researchers from other countries.

KEY WORDS: Aqua Regia, Erbil, Heavy metals, Thresholds.

INTRODUCTION

Heavy metals are among the most common environmental pollutants and their occurrence in soils indicates the presence of natural or anthropogenic sources. The main natural sources of metals in soils are weathering of parent material and soil erosion (Yoon J. *et al.*, 2007). The anthropogenic sources are associated mainly with industrial activities, combustion by-product, traffic emissions and other human activities such as agricultural practices (Omar and Al-Khashman, 2004).

Heavy metals in soil may have negative consequences on human health and on the environment (Mielke *et al*., 2005; Selinus *et al*., 2005). Their distributions in soils are well documented for many cities of developed countries, but little is known in less developed countries (Thuy *et al.*, 1999). In recent years in the city of Erbil, in addition to population growth and increased use of automobiles, a number of factories and industrial sites have been randomly developed which obviously have a negative impact on the environment. The study area covers south industrial and north industrial zones which are the biggest two sites for vehicle industrial activities, workshops and scrapyards. At present very little data are available on the extent of environmental pollution in the studied area as there are only few research centers with insufficient capacity. The municipality of the city has no adequate waste management plan; therefore high levels of contaminants, such as heavy metals, might have been released into the soil. The objective of this study is to provide baseline information on the anthropogenic impact of environmental pollution in the industrial regions of Erbil. This study is important because it can be used as basis for planning management strategy to achieve better environment quality and substantial progress of the city.

MATERIAL AND METHODS

The north and south industrial area are located 4.6 km and 4.5 km away from the city centre of Erbil respectively. They cover a total area of 231donum and 122 donum which are equivalent to 0.58 km^2 and 0.31 km^2 respectively. They are the biggest industrial area in the city with heavy servicing vehicle activities. The samples were selected in order to cover the entire area of the servicing workshops. Nineteen surface soil samples (0-5 cm) were collected using a stainless steel spatula. The collected soil samples were air dried at room temperature and sieved through a 2 mm sieve. The <2 mm fraction of the soil was used for analysis after they were oven dried for 18 hours at 105 ^oC. Electrical conductivity (EC) and pH were measured in a soil deionized water suspension (soil: water, 1:2.5 by volume) by a calibrated pH meter and conductivity meter respectively (ISO, 2002a). Total organic matter contents were determined by soil ignition at

temperature of 450 ^{o}C (Allen et., al., 1974). Cation Exchange Capacity CEC of soil samples were analyzed for CEC using the ammonium acetate method at pH 7 (Chapman, 1965)**.** The samples were digested using aqua regia (ISO, 2002b). The solutions of the digested samples were analyzed using air/acetylene atomic absorption spectroscopy (UNICAM 929 model) with the use of prepared standards for Cu, Ni, Cd, Zn, Pb and As. Calibration curves were used to calculate the concentration of the metals.

RESULTS AND DISCUSSION

The results of the chemical analyses of the study areas are given in Table 1. The values of pH ranged in a narrow interval from 8.53 to 8.84 with an average value of (8.68 ± 0.1) which indicates alkaline conditions for all the top soils. The electrical conductivity of the soil samples were between 0.45 and 0.65 ds.m^{-1} with an average value of (0.54 .± 0.06 ds.m^{-1}). The cation exchange capacity (CEC) of the samples ranged between 24.47 and 28.54 meq/100g with a mean value of (25.73 ± 1.31 meq/100g). The total organic matter contents (TOM) in the samples were ranged between 9.28% and 13.84% with the mean value of (11.85% ± 1.3). The high contents of TOM probably are due to the high organic content of used oils and lubricants that were discharged at the site. The mean value of EC, CEC, and TOM of the soil samples collected from the south industrial area were slightly higher than those collected from the north industrial area with the value of 0.58 ds.m^{-1} , 26.38 meq/100g and 12.55% for south industrial samples and 0.47 ds.m-1 , 24.63 meq/100g and 10.66% for the samples of north industrial area (Figure 1). This is probably due to higher number of workshops and greater work activities in the south industrial area which was relatively apparent compared to the north industrial site.

Table (1): Some properties of surface soil samples from the south and north industrial area of the city of Arbil.

South industrial area	pH	EC ds.m^{-1}	TOM %	CEC meq/100g
S1	8.65	0.58	11.33	25.46
S2	8.67	0.50	12.12	25.79
S3	8.77	0.55	12.21	25.80
S4	8.54	0.58	12.90	25.78
S5	8.59	0.58	12.75	25.67
S6	8.76	0.65	12.28	25.67
S7	8.77	0.61	12.87	25.59
S8	8.53	0.59	13.34	27.39
S9	8.54	0.61	13.14	27.64
S10	8.54	0.58	10.84	24.78
S11	8.53	0.55	13.02	28.39
S12	8.84	0.52	13.84	28.54
North industrial area				
S13	8.72	0.48	9.84	24.47
S14	8.76	0.50	9.28	24.49
S15	8.77	0.45	9.73	24.80
S16	8.72	0.48	11.35	24.70
S17	8.75	0.48	10.94	24.57
S18	8.77	0.45	12.10	24.77
S19	8.71	0.45	11.36	24.59
Mean	**8.68**	**0.54**	**11.85**	**25.73**
STDEV	**0.10**	**0.06**	**1.30**	**1.31**

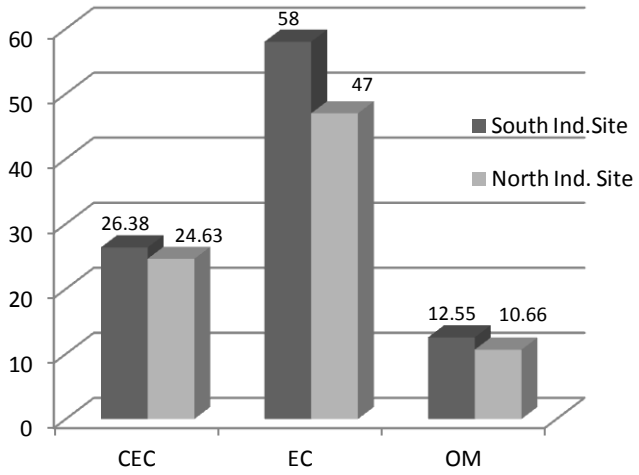

Fig. (1).: The mean value of CEC, EC and TOM for north and south industrial area

Concentrations of Cu, Zn, Cd, Pb, Ni, and As in the studied soil samples of both northern and southern industrial sites together with their mean values and standard deviation are listed in the Table 2. As there is no international agreement on metal concentrations in soil that constitute significant contamination, in this study our results were compared to the heavy metal values reported by EPA (2006), Adriano (2001), McGrath and McCormack (1999), and HG regulation 10/2000 (2000) as shown in Table 3.

The measured concentration of nickel had the highest mean value of (66.64 µg/g ± 1.65), followed by lead (24.32 µg/g ± 0.37), Arsenic (17.56 µg/g ± 0.92), Copper (7.30 µg/g ± 0.51), Zinc (2.07 µg/g ± 0.45), and Cadmium (0.66 µg/g ± 0.09). Compared to the average values given in Table 3, the mean value of Ni and As in the analysed soils were higher than thresholds reported by EPA (2006), H.G number 10-200, and McGrath & McCormack (1999), therefore it can be concluded that the

Table (2): Total concentrations (µg/g) of heavy metals in the surface soils ofthe South and North Industrial area in the city of Erbil

South Industrial Area	Cu	Zn	Cd	Pb	Ni	AS
S1	6.66	1.51	0.52	23.56	63.1	15.33
S2	6.78	1.42	0.55	23.55	63.8	15.48
S3	6.43	1.55	0.61	23.67	65.2	16.72
S4	6.84	1.59	0.64	24.56	65.8	16.74
S5	6.94	1.54	0.61	24.34	65.5	17.45
S6	6.93	1.73	0.70	24.43	65.9	17.55
S7	7.43	1.76	0.73	24.44	65.1	17.56
S8	7.38	1.83	0.75	24.45	67.4	17.57
S9	6.73	2.21	0.73	24.43	67.4	18.31
S10	6.70	2.01	0.78	24.70	67.8	18.42
S11	7.77	2.32	0.71	24.55	67.3	18.21
S12	7.69	2.34	0.77	24.57	65.2	18.11
North Industrial Area						
S13	7.77	2.33	0.55	23.76	67.3	17.66
S14	7.74	2.45	0.58	24.45	67.7	17.68
S15	7.87	2.05	0.67	24.49	68.7	17.73
S16	7.89	2.56	0.67	24.54	67.7	17.80
S17	7.73	2.63	0.52	24.57	68.5	18.49
S18	7.75	2.73	0.73	24.57	68.3	18.47
S19	7.75	2.78	0.76	24.49	68.5	18.35
Mean	**7.30**	**2.07**	**0.66**	**24.32**	**66.64**	**17.56**
STDEV	**0.51**	**0.45**	**0.09**	**0.37**	**1.65**	**0.92**

surface soil samples were contaminated with Nickel and Arsenic and this might be attributed to the effect of industrial activities and release of contaminants in the studied area (Figure 2). Whereas Levels of Cu, Zn, Cd and Pb with the mean value of 7.30, 2.07, 0.66, and 24.32 (µg/g) respectively were generally within the ranges of those reported for unpolluted soils (Adriano, (1986); EPA, (2006). Moreover from the inconsistency across the sampling area and therefore higher standard deviations, it can be suggested that distributions of the metals are not indigenous which are typical to anthropogenic contaminations and therefore the samples can be described as slightly to moderately contaminated with at least two metals (Ni and As).

Table 3. Concentrations and threshold limit of heavy metals (µg/g) in soils

	Cu	Zn	Cd	Pb	Ni	AS
Threshold limit value ***	1-50	9-125	0.1-1	10-70	0.5-50	3-12
Threshold limit value ***	15-40	50-100	0.1-2	15-30	15-30	0.1-15
Threshold limit value ***	50	250	1	50	30	15
Threshold limit value ****	75	200	1	100	40	15

* Data from "Interpreting Soil Heavy Metals" EPA (2006)
** Data from Adriano, DC (2001)
*** Data from McGrath and McCormack (1999)
**** Data from HG regulation 10-2000 (2000)

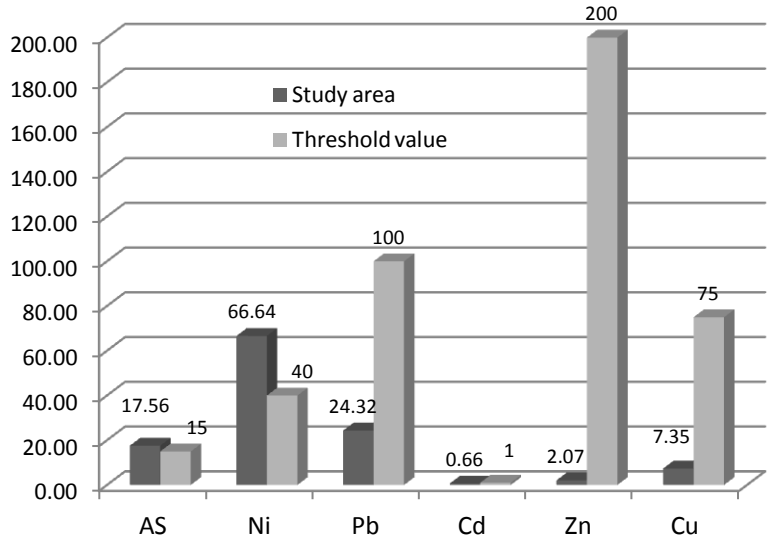

Fig. (2).: The mean value of Cu, Zn, Cd, Pb, Ni, and As in comparison to the threshold values given by EPA (2006), McGrath and McCormack (1999), and H. G. regulation number 10-2000 (2000).

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تێکڕای چڕی توخم سەنگی‌نهک‌ان لە چی‌نی سەرهوەی خاکی هەندێ ناوچەی پی‌شەسازی لە شاری هەولێر

پ‌وخت‌ە

چڕی توخم سەنگی‌نهک‌انی وهک As, Ni, Pb, Cd, Zn, Cu لە 19 نمونەی چی‌نی سەرهوەی خاک لە ناوچەی پی‌شەسازی باک‌ور و پی‌شەسازی باشور لە شاری هەولێر لە ڕێگ‌ەی بهک‌ارهێنانی ئامێری AAS پێوانهک‌ران دوای تواندنهوەی‌ان لە گی‌راوەی ئهک‌وا ڕی‌جا دا. هەروەها پ‌لەی ترشی، گ‌ەی‌اندنی ک‌ارهبایی، قەبارەی ئاڵوگۆڕی ک‌هتایۆنی و مادە ئۆرگ‌انی‌هک‌انی‌ش پێوانهک‌ران. لەم تویژی‌نەوەی‌هدا چڕی ئهم توخمانە بە (µg/g) تۆمارک‌ران و ڕێژەهک‌ان بهم جۆرە بوون: Ni (63.1-68.7), Pb (23.55-24.70), As (15.33-18.47), Cu (6.66-7.89) Cd (0.52-0.78), Zn (1.42-2.78). دهرئەنجامهک‌ان وای پی‌شان دا ک‌ە پێک‌هاتەی توخمی As و Ni زی‌اتربون لە لە ئاستی ڕێپێ‌دراو لەلای‌هن دهزگ‌ای EPA وتویژهرهوانی تری وڵ‌اتان.

التركيز الكلى للمعادن الثقيلة فى الترب السطحية لبعض المناطق الصناعية فى مدينة اربيل

خلاصة

تم قياس العناصر الثقيلة As , Ni, Pb, Cd, Zn, Cu فى 19 عينة ترب سطحية فى المواقع الصناعية الجنوبية و الشمالية فى مدينة اربيل مستخدما جهاز AAS بعد الذوبان الكلى بطريقة محلول اكوا ريجا. كذلك تم قياس درجة الحموضة، التوصيل الكهربائى، سعة تبادل الكتايونى و المواد العضوية لجميع هذه العينات. فى هذه الدراسة سجلت تركيز العناصر ب µg/g. تراوحت النتائج بين : Cu (6.66-7.89), Zn (1.42-2.78), Cd (0.52-0.78), Pb (23.55-24.70), Ni (63.1-68.7), As (15.33-18.47). النتائج تؤشر بان المحتوى الكلى للعنصرين الثقيلين Ni و As كانوا اكثر من الحد الاعلى المسموح به من قبل هيئة EPA و الباحثين الاخرين من الدول الاخرى.

USE OF LOCAL MATERIALS AS ADDITIVES FOR BRICK STABILIZATION

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ABSTRACT

An attempt was made to investigate the possibility of improving the quality of brick product before and after firing upon mixing sand and red Gercus materials with the Sumail silty clay soil at varying proportions (between 0 and 30% percent for sand and between 0 and 40% for red Gercus material). The results indicated that there was a continuing increase in the compressive strength of bricks with increasing the red Gercus content over the entire range from 0 to 40%. Over this range the compressive strength increased from 7.29 MPa for the control treatment to as high as 12 MPa under 40% of the red Gercus additive. Further increase in unconfined compressive strength was achieved under firing. Contrarily, it was noticed that the unconfined strength tended to increase with sand content up to a level of 10 %., beyond which, it tended to decrease with an increase in soil sand content. Additionally, it was noticed that there was a steady increase in water absorption with increase in red Gercus content over study range. By contrast, it was observed that further increase in sand content beyond 10% led to a decrease in the percent of water absorption. Based on water absorption percent, they were classified under type A. Efflorescence density of the tested bricks was not affected by type and level of additive. A part from this it was observed a tendency for development of redder color with increase in level of red soil additive. Eventually, it can be concluded that the optimum replacement percentages of sand and red Gercus materials were 10 and 20% respectively.

KEYWORDS: Brick stabilization, Use of red Gercus as an additive, sand additive

INTRODUCTION

A large variety of soils are suitable for brick manufacturing, the essential property of which being plasticity to facilitate moulding (Appropedia, 2009). Desirable soils for brick making are those classified as loamy sands, sandy loams and sandy clay loams (Kratzer, 2009). In these soils, the clay content never exceeds 30 percent or roughly one-third of the ingredients and the sand content is never less than 50 percent. It is reported that clays which are strong or plastic are known as fat clays they always contain a high percentage of true clay substance. Such clays take up a considerable amount of water in tempering; they dry slowly, shrink greatly and so become liable to lose their shape and develop cracks in drying and firing (Cmewa, 2009). Yalmaz and Bodur (2009) reported that the illite and kaolinite clays are the most suitable for brick-tile industry. Because montmorillonite has high shrinking and swelling properties, they are unsuitable for brick-tile industry, so Vertisols should not be used for tile manufacture. Ozisik (2000) stressed that plasticity index most suitable for brick materials ranges from 8 to 25%.

Stabilization of adobe refers to and treatment that gives its property permanence, strength, and dimensional stability. Numerous materials are in use today for stabilization. They include sand, gravel, fibers, bitumen, chemical products, cement pozzolona, lime and gypsum (Tanacan, 2008). The manufacturer minimizes variations in chemical composition and physical properties by mixing clays from different locations in the pit from different sources (BIA, 2009). Fat clays are greatly improved by addition of coarse sharp sand, which reduces the time of drying and shrinkage and makes the brick more rigid during the firing (Cmewa, 2009). Mouluid (2009) reported that addition of sand to clay soil acts as an additive that modifies the raw materials use for brick making. The finding of his experiment indicated that the dry compressive strength show maximum strength value of 192 kg cm-2 at 15% sand content. Beyond 15% the strength curves declined gradually. This was due to bond weakening or decreasing cementing force between boned particles. Also it was revealed that there was appreciable increase in compressive strength and improvement in durability of soil blocks by the addition of stabilizers, like lime and / or cement than the ordinary un stabilized soil block which got

eroded due to effects of rainfall. In general, most inorganic soils can be stabilized with Portland cement except heavy clays (Abdul-Kader, 1986).

Free iron oxides (Fe2O3) case an increase in hardness at the end of furnace and giving a red color. The Fe content preferred to be 8 – 10 % Yilmaz and Bodur, 2009). Clay rich in iron burns red when exposed to an oxidizing fire, due to the formation of ferrous oxide and due to the valence state of iron influenced by the firing conditions (Khan, 2008). The color of bricks can be changed by adding chemicals to the raw materials or by changing the atmosphere of the kilin. For instance reducing oxygen of a kiln, a darker brick is produced than that produced under normal conditions (Karaman et al., 2006). A possible defect of burnt bricks is efflorescence, which appears temporarily on the surface of the brick and is caused by soluble salts inherent in the clay or process water (Appropedia, 2009). Since the silty clay soil at Sumail site occupies an extensive area and unsuitable for brick manufacturing, the present work was undertaken with the main objective of improving the quality of brick product made from this soil by incorporating two types of additives at varying levels with it.

MATERIALS AND METHODS

1. Experimental Materials

A bulk soil sample was collected from the top 0.5 m of Sumail soil. Upon bringing the soil to the laboratory, it was air dried and gently grounded to pass through 4-mm sieve. Furthermore, bulk soil samples were obtained for two additives, namely, the red Gercus soil from Bajlor soil and construction sand from Khabour River. Each additive was air dried and gently crushed to pass through a 4- mm sieve.

2. Experimental Design

The red Gercus sub experiment encompassed 5 levels. They were obtained by mixing specified amounts of red Gercus soil with Sumail soils at rates of 0, 10, 20, 30, and 40 % by weight. Beside that the second sub experiment included 4 levels of sand. They were obtained by mixing specified amounts of construction river sand with Sumail soil at rates of 0, 10, 20 and 30%. Each sub experiments was laid in a completely randomized design with three replicates.

3. Experimental Work

The dry ingredients for the mix were mixed together thoroughly before water addition. Next brick specimens were prepared by adding specified amounts of water to each mixture to make a paste with a water content of about 35%. Each batch was kneaded for roughly ten minutes or until cohesiveness and fair workability was achieved. The bricks were formed immediately following the preparation of the mix. The bricks were produced in batches of 12 – 15 bricks using 23 cm x 11.7 cm x 7 cm bottomless moulds that were continuously oiled to facilitate removal of bricks. The moulds were placed on a wooden surface over which a thin layer of sand was spread to prevent sticking. The mix was compacted by hand as much as possible to prevent air voids. Excess mud was scraped off with a trowel. The sample bricks were then placed in a room of 23 ± 5 o C for a period of 60 days. About 150 bricks were manufactured. Subsequent to air drying, about two thirds of the brick specimen was fired in a furnace, heated at 1200 ^{o}C for 45 h at Kwashi brick factory, 5 km to the west of the experimental site. Thereafter, the bricks were subjected to some selected engineering tests before and after firing particle sized distribution was carried out by combination of sieving and hydrometer according to Klute et al. (1986). The total soluble salts, sulphate content, and the pH of the soil extract were measured according to the standard methods described by Richard et al. (1954). Organic matter content was determined by the wet oxidation method of Wakley-Black modified (1965). Calcium carbonate equivalent was determined by acid neutralization method (Richards, 1954). Percent of linear shrinkage was determined following the procedure of BSI 1377 (1975). Liquid limit was measured according to ASTM D423, 1986, while plastic limit and plasticity index were determined according to ASTEM D424, 1986. Table1 exhibits some selected physical, chemical and geotechnical properties of the study soils. Further, Table 2 displays some selected properties of the applied additives. Statistical analysis was performed using Statgraphics software v plus 4. The means of the treatments were compared using least significant difference (LSD) at ($P \leq 0.01$).

RESULTS AND DISCUSSION

Materials Characterization

Although the base soil has some selected properties which satisfy the requirements of raw materials for brick manufacturing, it possesses some undesirable properties from brick production view point. Amongst the suitable

properties are low dissolved salts (< 1.5 %); low calcium carbonate content (< 25%); low soil organic matter content (< 3%); non-acidic reaction (pH > 7.0), low sand content (< 50%). In contrast to the above suitable properties, it is a fat soil (LL > 50%) and grouped as clay of high plasticity, medium potential to swell and shrink (PLS = 13%). The high level of plasticity is unsuitable for brick manufacturing. The high plastic clay absorbs high amount of water (Yilmaz and Bodur, 2009). Additionally, the dominant clay mineral is montmorillonite (34%) (khalid, 2002). Such base soil takes a considerable amount of water in tempering; it dries slowly, shrinks greatly and so becomes liable to lose their shape and develops cracks on drying and firing. This implies that local soil is not found to be practical for making bricks. Since it is not economical to import the raw materials from other locations, this study was designed to improve the quality of the base soils by blending additives. Table (1) also revealed that the red Gercus material has some desirable properties like lo w salt content, low percent of linear shrinkage, relatively lower montmorillonite content and a high percentage of iron oxides (9.08%).

Property		Unit	Average value			
			Base soil	Red Gercus additive	Sand additive	*Recommended values
Particle size distribution	Sand	g kg^{-1}	8.4	28.4	86.9	50-75
	Silt	g kg^{-1}	50.1	45	3.75	25-50
	Clay	g kg^{-1}	41.5	26.6	9.35	25-50
	Textural name		Silty clay	Loam	Loamy sand	
Organic matter content		g kg^{-1}	2.03	0.85	0.34	<3
Calcium carbonate equivalent		g kg^{-1}	12.4	51.5	16.23	<25
pH		–	7.93	7.11	7.92	>7.0
Total dissolved salts		(%)	0.20	0.10	0.18	<1.5
Sulphate		(%)	0.05	0.03	0.13	<2
Soil indices	Liquid limit	(%)	51	54.4	24.31	<50
	Plastic limit	(%)	26.5	44.04	20.2	<30
	Plasticity index	(%)	24.5	10.36	4.11	<20
Linear shrinkage		(%)	13.19	4.92	2.85	<9
Dominant clay minerals		(%)	Monti+kao	Monti+Chl+paly+kao+illite		Rich in kaolinite and illite
Free iron oxides		(%)	5.48	9.08		8-10

Table 1. Description of the base soil and the applied additives along with the optimum values of the properties for brick manufacturing.

Apart from this, it is a fat soil with high calcium carbonate content. Moreover the results of Table1 indicated that the salt, organic matter and carbonate contents of the sand additive were very low. It was also characterized by having a relatively well graded curve (Fig.1).

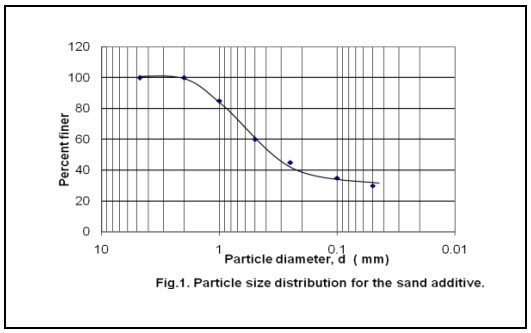
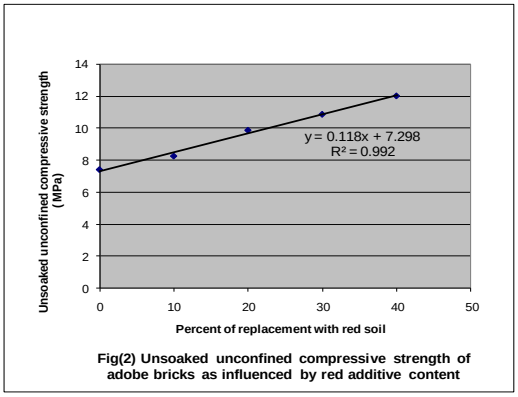


Fig.1. Particle size distribution for the sand additive.

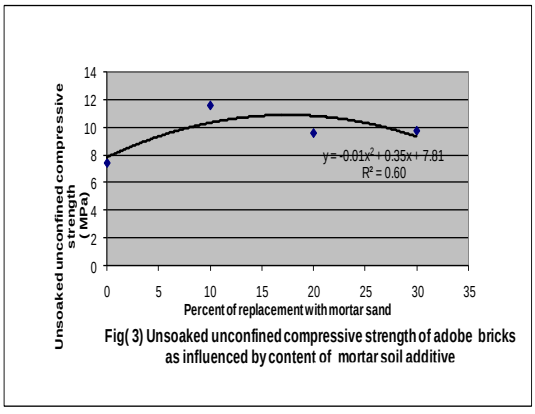
Unconfined Compressive Strength

The sun baked bricks were tested for their unsoaked unconfined compressive strength as influenced by replacement with red Gercus over a range from 0 to 40% (Fig.2). It can be seen that there is a continuing increase in the compressive strength of bricks with an increase in the level of the additive over the entire range from 0 to 40%. The compressive strength ranged from as low as 7.29 MPa for the control treatment to as high as 12 MPa for the replacement treatment of 40%. The linear relationship left less than 1% of the variability in compressive strength unexplained. At this stage, even the maximum compressive strength is below the minimum compressive strength for construction. This means that they are less than 173.3 kg m^{-2}(17MPa). Apart from this the compressive strength at a replacement of 20% and beyond are more than 85 kg cm^{-2}(8., i.e., the bricks with replacement of $\geq$ 20% are suitable for partitions (Mouluid, 2009) Upon firing at 1200 oC, the burnt bricks attained a compressive strength of 31.99 MPa when the soil additive content was 20%. Additionally, it was raised to 35.73 MPa as the additive was increased to 40%. The increase in the compressive strength with increase in the additive content may be due to an increase in sand content on one hand and an increase in the free iron oxides on the other hand. The Fe content in form of oxides preferred to be in the range of 8- 10 %. (Yilmaz and Bodur, 2009). The amorphous materials (free iron oxides) played a major role in improving the brick quality before and after firing through cementing the soil particle of the base soil together.



Fig(2) Unsoaked unconfined compressive strength of adobe bricks as influenced by red additive content

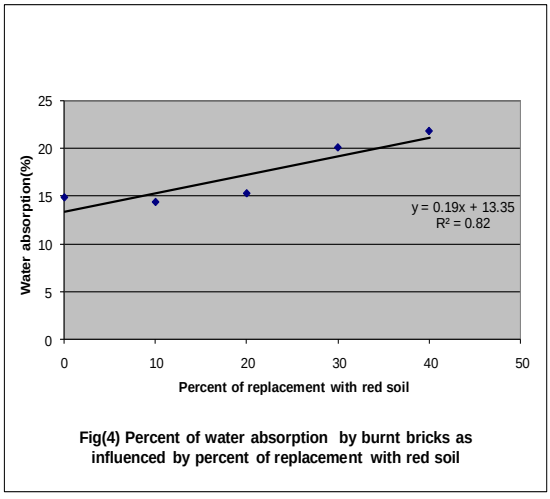
To determine the contribution of coarse materials on improving the unconfined compressive strength of the fabricated bricks, mortar sand was incorporated at 0, 10, 20 and 30 to the base soil and the results were displayed in Fig.3. The results of Fig. 3 indicated that the unconfined compressive strength with an increase in soil sand content up to a level of 10%, beyond which it tended to decrease with an increase in soil sand content. It is also clear that the parabolic function explained only 60 % of the variability in compressive strength. The optimization procedure revealed that the maximum compressive strength was 11 MPa and the corresponding sand content was 17.55%. This result is in compliance with the finding of Mouluid (2009) who found that the optimum sand content for Arbil brick products was 15%. Unfortunately, the majority of the fabricated bricks under the sand treatment failed to give reasonable compressive strength. Interestingly, unconfined compressive strength for sun baked and burnt bricks get further enhanced with increasing compaction pressure. This will cause an increase in soil density and as a result gives rise to an increase in compressive strength.



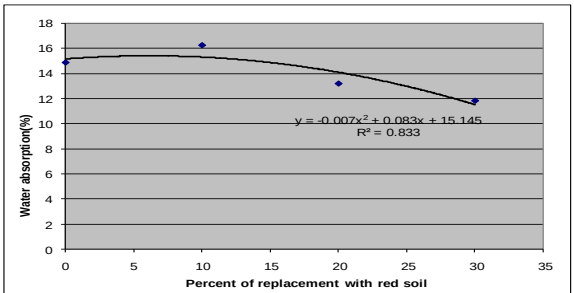
Fig(3) Unsoaked unconfined compressive strength of adobe bricks as influenced by content of mortar soil additive

Water Absorption by Fabricated Bricks

The burn fabricated bricks were also tested for their water absorption and the results were presented in Figs.4 and 5. It can be noticed from Fig. 4 that as the red Gercus content increased the water absorption increased too. The linear model explained 82% of variability in water absorption. The increase in water content may be partly due to increase in porosity on account of an increase in sand content. The increase in soil colloidal content may be another reason for increased water absorption because the colloids have great affinity to absorb water. Additionally, it can be noticed from Fig. 5 that as the sand content increased from 0 to 10%, the percent of water absorption increased from 14.84 to 16.21. Further increase in sand content beyond 10% led to a gradual decrease in percent of water absorption. These results are inconsistent with the findings of Mouluid (2009) who noticed a continuing increase in percent of water absorption as the sand content increase from 10 to 17.5%. It seems from the above results that different soils behave differently based on differences in soil composition. Furthermore, water absorption is affected by methods of manufacturing and firing (Teixeira et al., 2001). Irrespective of the type additive and its level and with no exception, the percent of water absorption for the fabricated bricks was below 22%. This implies that these bricks can be classified as type A according to the Iraqi Specification No. 25/1988 and can be used in areas subjected to frost action at or below the ground level.



Fig(4) Percent of water absorption by burnt bricks as influenced by percent of replacement with red soil



Fig(5) Percent of water absorption by burnt bricks as influenced by percent of replacement with mortar

Efflorescence

Efflorescence test of the burnt brick samples indicated that with no exception the efflorescence density was light (Table 2). This implies that this parameter was neither affected by type of additive nor by additive level. This can be attributed to the low dissolved salt content of the base soil and additives.

Table (2): Efflorescence density as affected by type and level of additive**.**

Type of additive	Additive level (%)	Efflorescence density				
		Nil	Light	Medium	Dense	Very dense
Red Gercus	0		√			
	10		√			
	20		√			
	30			√		
	40			√		
Sand	0		√			
	10		√			
	20		√			
	30		√			

Brick Color as affected by type and level of additive

Table 3 revealed that the colors of the sun baked and burnt bricks were affected by both additive type and the additive level. It is apparent from the results that the hue of the sun baked bricks tended to decrease from 10 YR to 5 YR as the red Gercus of the base soil increased from 0 to 10%. Apart from this, the hue of the burnt color was not affected by the level of the red soil. Moreover, it was noticed the chroma of the burnt clay tended to increase from 6 to 8 upon application of the red soil. Unlike the treatment with red Gercus soil, in general no obvious trend was noticed upon the sand application. Overall, it can be seen that there is a tendency for development of more red color with increase in level of red soil additive. A clay containing from 5 to 8% of oxide of iron will under ordinary conditions of firing, produce a red brick; but if the clay contains 3 to 4% of alkalis, the color will be darker and more purple (Cmewa, 2009).

Table (3): The effect of additive on brick stabilization

soil treatments	Additive red Gercuse	Comp. stre.
T1	70.4433	0.00
T2	83.6700	0.00
T3	99.8333	314.427
T4	97.1667	263.297
T5	121.3700	363.370
T6	70.5367	0.00
T7	118.3567	0.00
T8	97.4933	0.00
T9	99.4867	0.00
LSD	1.4877	8.6102

CONCLUSIONS

It can be concluded from the current study that mixing the Sumail soil (as a typical caly) with red Gercus and sand additives at replacement ratios of 20% and 10% respectively, were optimum for brick manufacturing in the region. Irrespective of type and level of additives, all the manufactured were grouped under Type A according to the Iraqi Specifications.

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بكارئينانا هندەك كەرەستێن نافخويى وەك زێدەكەر بو باشكرنا خوەگريا تابوكا

پوختە

پێكولّەك هاتەكرن بو هەلّسەنگاندنا باشكرنا جورێ تابوكا بەرى وپشتى قەلاّندنێ بەرێ يا تێكەلكرنا خيزێ ئافاكرنێ و ئاخە سوّرێ دگەل ئاخا سێميلێ ب ريژێن جودا هەر ژ (سفر -30%) بو خێزێ و هەر ژ (سفر-40%) بو ئاخە سوّرێ. ئەنجامان ووسان خوياكر كو تابوك قاهيمتر لێ دهێت ب زێدەكرنا ريژا ئاخەسوّرێ. ئەوژى قاهيميا وێژ7.29Mpa بو نموونا كونترولێ هەتا گەهشتيە 12Mpa(Red Gercus) بو ريژا تيكەلكرنا 40% . بەروڤاژى ڤێ جەندێ ئەنجامان ووسان ديار كر ب زيدەكرنا ريژا خێزى دناڤ ئاخەسوّرێ دا قاهمييا وان ل كێمێ دا . هەروەسان (مژينا ئافێ) ب زێدە كرنا ئاخە سوّرێ زێدە بوو وب زێدە كرنا ريژا خێزێ كێم بوو. لسەربنەرەتێ (ئاڤ مژينێ) تابوك هاتنە ڤاڤارتن و ژجورێ (A) هاتنەّ هژمارتن . هەروەسان ديار دا راڤێن سپێ (Effloresence) ب جورو ريژا زێدە كرنا خێزى و ئاخەسوّرێ نەهات گوهرێن. لێ رەنگێ تابوكێ بەرەڤ سوّراتيێ چوو ب زێدەكرنا ئاخەسوّرێ و ب ڤێ جەندێ ئەم دشێين ئەنجامان ووسان ديار كەين كو باشترين ريژا زيزێدەبوونێ بو خێزێ وئاخەسوّرێ ريژاى10 -20% لدووێ ئێك.

استخدام مواد محلية كإضافات لتحسين ثباتية الطابوق

الخلاصة

جرت محاولة لاختيار إمكانية تحسين نوعية الطابوق قبل وبعد الحرق عن طريق خلط Sand وRed Gercus مع تربة سيميل (المزيجية الطينية) بنسب مختلفة بين (صفر – 30%) وSand بين (صفر -40%) .أظهرت النتائج زيادة في صلابة الطابوق بزيادة نسبة Red Gurcus بنسب من صفر– 40%.حيث زادت من 7.29Mpa لمعاملة المقارنة و 12Mpa لمعاملة 40%. على العكس أظهرت النتائج انخفاض في صلابة الطابوق بزيادة نسب الرمل وزاد الماء الممتص بزيادة نسبة Red Gercus وقل بزيادة محتوى الرمل 10%. اعتمادا على نسبة امتصاص الماء صنفت ضمن النوع A. لم تتأثرصفة التزهر Effloresence للطا بوق تحت الدراسة بنوع ونسب المواد المضافة , بينما ظهر اللون مائلآ للاحمرار بزيادة نسب red Gercus , لذا يمكن الاستنتاج بأن أفضل نسب للإضافة كل من الرمل و Red Gercus هي عدد (10 و 20%) على التوالي .

FINANCIAL AND ECONOMIC PHYSABILITY OF PLANE TREE (*Platanus orientalis L.*) STANDS IN DUHOK GOVERNORATE*

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ABSTRACT

Plane tree, *Platanus orientalis L.* is a native tree species and one of the largest deciduous in the region and in Iraq. Its wood is of high quality that makes it suitable for producing upper end products. Yet this species have not been used for establishing plantations in Kurdistan region. Two regimes, with and without vegetable production, were tested. In financial analysis, producing vegetable slightly improved values of financial criteria except for benefit cost ratio criterion, while in economic analysis, all the criteria favored not producing vegetable except for inernal rate of return criterion. Sensitivity and break even analyses reviled that this type of plantation is quiteer save investment.

***KEYWORDS**:* Duhok, *Platanus orientalis* L., Plantation, Financial feasibility, Economic feasibility.

INTRODUCTION

Despite the immense importance of the world forests for the mankind, its area is decreasing by 7 million hectare in each year and there is no indication that this rate is slowing down (FAO, 2005). One of the main reasons for this reduction is over exploitation to meet the world demand for wood. The total extent of industrial wood plantations in the world is about 1.03 million km^2. This area comprises about 3% of the world natural forest area (Brown, 1999). The establishment of forest plantations is considered as an integral part of the long-term forest resource management strategy. Hence, the area of plantations was increasing by about 14 million hectares during 2000-2005, or 2.8 million hectares per year (FAO, 2005). Muuss et al. (2007) state that, for the period 1992 to 2007, the share of industrial fiber from plantations has grown from 5 to 30 percent. Thus, one can conclude that the world is increasing reliance on plantations for providing woody row materials. It is also resorting to intensive forest management to enhance growth and yield. This will contribute in reducing pressure on natural forests and sooth the effect of one causes of deforestation of natural forest.

Natural forest of Iraq cannot sustainably furnish Iraqi market with roundwood. Therefore, Iraq relies on imports to meet its demand for lumber. Poplar plantations are established all over Kurdistan Region, but the wood of poplar is not good for high quality woody products. Plane tree wood is of good quality and its stands have successively been established in Nineveh plantation about 60 km south of Duhok governorate. Establishing plane tree plantations in Duhok will provide the opportunity to reduce reliance on import to meet Iraqi demand for lumber.

Intensive management is required in order to achieve good yield in both quantity and quality. The silvicultural treatments need to be applied include fertilization, watering, pruning, thinning and weeding. The yield of plane tree has not been adequately investigated in Iraq or in other parts of the world. Salih *et al*. (1989) used stand table projection to estimate growth during the following five years (age 22-27 year) for plane tree stands at Nineveh plantation. They estimated the yield at age 22 to be 184.16 m^3/ha. This means that the mean annual increment (MAI) was 8.4 m^3/ha/year. It is believed that irrigation is the only silvicultural treatment that was adequately applied. Even this treatment was drastically reduced since early 1980es. Therefore, much better figures for MAI could be attained if intensive management is applied.

Both financial and economic feasibility studies are required to ensure the sustainability of plane tree plantations. The financial analysis deals only with those goods and services for which people pay or are paid, and it deals with the actual monetary payments involved such as

labor, capital and land. Financial analysis always have to be done from a specific interested party's point of view-government agency, private firm or individual, cooperative,…etc. (Gregersen and Contreras, 1992). In economic analysis, society is concerned with the costs and benefits to society as a whole, regardless of who pays and who gains. It also deals with benefits measured in

* Part of third author's thesis

terms of what society actually is willing to pay for goods and services and costs in term of the opportunity costs involved. This work was carried out in 2008 aiming at assessing the financial and economic feasibility of a 250 hectares plane tree plantation.

MATERIALS AND METHODS

Plane tree, *Platanus orientalis L.* is a native tree species and one of the largest deciduous in the region and in Iraq, it reaches up to 30 m height. Shahbaz (1979) found that plane tree wood is tough and difficult to split and work because of relatively high specific gravity (0.6-0.8) and straight-grained fiber of its wood. He also found that the wood of this species has high maximum strength and very high modular of elasticity. The elevation range of plane tree extends from sea level 1000-1500 m (Dawod,

1979). The tree grows in clay, loam, sand, acidic, alkaline, extended flooding, and well drained soil. Duhok Governorate is located in the far North of Iraq (North-east of Kurdistan Region). It is bounded by latitude 36.4 – 37.2 North and Longitude 42.2 – 44.1 East (Al-Janabe, 1985). The weather is continental with rainy cold winter and hot dry summer. Precipitation ranges from 450mm to 1000mm. In general the land is mountainous with plane in the south (Directorate of Meteorology in Duhok Province, 2009). Due to the relative scarcity of the information on plane tree plantations in the region, assumptions regarding yield and prices could not be obtained on solid bases. Hence, the methodology of this work was carefully developed to cover the uncertainties associated with this project.

Plantation's Layout

In this work two regimes were considered, the first one assumed to start with close initial spacing (2.0 X 2.5 m). Thinning application was designed to encourage diameter growth and to generate income at early stage of project life. Thinning was assumed to be implemented at early stage of stand development and applied at short intervals. This is because trees grow at a fast rate at the early stage of stand development. The second regime assumed to embark on wide spacing (2.5 X 4 m) in order to be able to produce vegetable crops (cucumber for example) between lines of trees for the first two years of project life. This practice will generate income in the early stage of project life which will expect to cover some

of the establishment costs, without incurring additional costs except for seedling, planting, and tending the crop. Table 1 demonstrates timing and intensity of thinning assumed for both regimes. Busby (1979) estimated Percentage of the area for roads, and irrigation and drainage canals to be 25% of large scale plantations. Since no drainage channels are required for the study area because of the depth of water table and the plantation scale is a moderate one, this figure was reduced to 10%. Hence the net planted area will be 225 hectares.

Table (1):- Timing and intensity of thinning of the considered regimes.

Year	First Regime			Second Regime		
	Percentage of Removed Trees	Number of Left Trees in ha	Number of Removed Trees in ha	Percentage of Removed Trees	Number of Left Trees in ha	Number of Removed Trees in ha
0	-	2000	-		1000	0
3	50%	1000	1000	0%	1000	0
7	50%	500	500	50%	500	500
11	25%	375	125	25%	375	125
15	20%	300	75	20%	300	75
24	100%	0	300	100%	-	300

Project Costs

Site preparation is an essential silvicultural treatment which greatly contributes in obtaining high yield. It, however, comprises a main component of the total costs since its value is not affected by discounting. Appendix 1 shows the cost of different inputs while appendix 2 presents the activities of the first regime (without vegetable production), output for labor and machine besides their costs. Appendix 3 presents analogous information with regard to second regime (with vegetable production).

Fertilization has been found a profitable treatment both in research and on commercial

scale for pine plantations (Hassan, 1986). Fertilization of plane tree has not been investigated, yet it was assumed that the proposed plantations will be fertilized. Nitrogen was assumed to be annually applied at a rate of 100 kg/ha, while phosphorus was assumed to be applied at years 0 and 7 at a rate of 200 kg/ha. Since the objective of plantations establishment was to produce high quality timber free from knots, pruning was assumed to be carried out annually until year10. This cost was considered to be constant over years. Pruning is labor intensive activity and costly, therefore it was assumed to be concentrated on those trees that are potential to be harvested in the final thinning and clear cut.

For the first regime, plantation's layout starts with 2 X 2.5 m spacing in order to reduce cost of weeding without excessively increasing cost of planting. For the second regime, cost of weeding was expected to be greater because of the wider initial spacing (2.5 X 4 m). For both regimes, cost of weeding was estimated together with the cost of cleaning ditches and water courses. Weeding costs were assumed to descend as trees grow up because trees will reduce the space for them to grow. It was also accounted for the increase in weeds after each thinning. Although plane tree does not have devastating insect or disease attacks, allowances were made for protection against them. Cost of maintenance of main ditch for both regimes was also considered. Allowances were also made for replanting on the assumption that mortality will be 5%. Cost of road maintenance was also taken into account. Appendix 2 and 3 present these costs for both regimes. No attempts were made to estimate cost of thinning since stumpage prices were used to calculate timber revenue.

Other Costs

Cost of land is an important element of the cost structure of forest projects. It was assumed to be equal to the current leasing fee levied by General Directorate of Agriculture in Dohuk on irrigated agricultural land which is ID12000/ha/year. This figure is extremely low, therefore, it was further dealt with in sensitivity analysis. The cost components of vegetable production (cucumber) consisted of cost of seeds where each hectare requires 3.2kg of seeds (Metlobs *et al*., 1989) at a cost of ID100000/kg. Cost of labors where 80 labor days are needed at cost of ID20000/labor/day. Cost of fertilizer where 100 kg of nitrogen at cost ID25/kg and 200kg of Phosphorus at cost ID30/kg were assumed.

It was assumed that a small building of total 40m² will be constructed, cost per m² was assumed to be ID240000 and total cost of the building will be ID9600 000. Cost of furniture was assumed to be 10% of building cost (ID960 000). Annual maintenance cost for the building was assumed to be 1% of building cost (ID96000). Staff consisted of a project manager with annual cost of ID7200 000 and 6 guards and labors with total annual cost of ID21600 000 were considered. Cost of staff was increased by 12% to account for social security, these cost will be on annual basis, starting from year 0. Due to the existence of permanent skilled labors, labor costs of other activities were reduced by 20%.

The project will need a truck. Purchasing price for truck was assumed to be ID20000 000. The annual maintenance and operation costs of truck is assumed to be 10% of its cost (ID2000 000). It was assumed that the project will require water pumps with total output of 1000 m³/hour. Six water pumps are assumed to be purchased, the output of each one is 200 m³/hour. The cost of each water pump was assumed to be ID2060 000 per piece and the cost of all water pumps were ID12355 000. The life of these water pumps was assumed to be 5 years. Annual maintenance and operation cost was also assumed to be 10% which is equal to ID1235 000.

Costs of building, staff, water pumps, and truck were divided by 225 in order to convert this cost to per hectare bases.

The replacement costs for water pumps and truck were assumed to be 90% of purchasing price. Replacement cost of water pumps expected to be ID11124 000 occurring in years 5, 10, 15, and 20, assuming a life of 5 years. With respect to truck, the replacement cost would be ID12000 000 occurring in years 10, 20 assuming a life of 10 years and replacement cost to be 60% of purchasing price. These costs were divided by 225 to convert it to cost per hectare. In order not to ignore costs that were not accounted for in the previous sections, total costs in each year were increased by 5% then the costs arrived at have been further increased by 7% for contingency. This will make costs estimation more conservative, hence reducing the probability of underestimating project costs.

Financial Revenues

The current stumpage price for poplar in the region, which is a well established price, is about ID150000/m³. Plane tree timber is superior over poplar timber because its wood has much better mechanical properties and, as a result, it is used for more valuable products and should have higher price. The FOB prices for teak roundwood are highly variable depending on size and quality. They range from $250/ m³ to $1000/m³ depending on size and quality. The management regime proposed for this analysis allow to produce high quality timber free form knots, the size of the wood, however, is not expected to be large since the chosen rotation age, 25 year, will not allow to have very large diameters. In the light of above discussion, plane tree stumpage prices were set to (in ID/m³) 140 000 , 257000, 374000, 433000, and 550000 for the first, second, third and fourth thinning, and the final harvest respectively according to the size expected from each thinning. Although these prices are conservative, it still bare uncertainty due to inexistence of market price both at local and international levels. Therefore, timber prices will further be dealt with in sensitivity analysis.

As stated earlier, the MAI of plane tree was in the neighborhood of 8 m³/ha/year in stands that have not been well tended. This means that much greater MAI could be attained if intensive management is applied, especially if the plantations are established in its natural habitat. Figures for MAI of sycamore (*Platanus occidantalis*) recorded in the USA exceeded 30m³/ha. Table 2 presents timber revenue outflow for both regime.

Table (2): Timber revenue outflow for first and second regimes per hectare in ID1000

Year	Price (ID 1000)	First regime		Second regime	
		Quantity (m³/ha)	Revenues (ID1000/ha)	Quantity (m³/ha)	Revenues (ID1000/ha)
3	140	5.5	770	0	0
7	257	49.5	12722	49.5	12722
11	374	44	16456	44	16456
15	433	38.5	16671	38.5	16671
24	550	275	51250	275	151250

Vegetable production in the second regime were expected to yield 10 ton/ha in year 0 and 8 ton/ha in the first year (Hassan *et al.*, 2002). This reduction in productivity was allowed to cover for the increased competition by plane trees in first year. At farm vegetable price was set to ID300000/ton based on current local prices. Using the procedures above vegetable values for the first and second years turned out to be ID3000000 and ID2400000 respectively. Depending on management objectives, there are many other values for the intended plantations such as recreation, grazing, fuelwood. However, no attempts were made to include their values, to avoid over estimation of revenues, but their values were included in the economic feasibility analysis.

The capital assets that were considered for salvage values are building and truck. The last truck was bought at year 20 and worked for 5 years before project ended. Its salvage value was calculated following the steps below:

1. It was assumed that the life of the truck is 10 years. The purchase price was ID20000 000 and will be sold at the end of year 10 for 40% of its purchasing price (ID8000 000).

2. An equal annual depreciation was assumed and calculated to be (20000000 – 8000 000) /10 = ID1200 000

3. Since the last truck was used for only 5 years there will be 5 years left of its life.

5 X 1200 000 = ID6000 000

This will be added to its scrap value(ID8000 000).

6 000 000 + 8 000 000 = ID14 000 000

4. To convert this cost to per hectare bases it was divided by 225.

Assuming the building life is 50 years and the scrap value is 5% of the building cost and using the procedures above, salvage value for building turned out to be ID4800 000. With respect to water pumps. The salvage value was the scrap value. In order to be conservative in estimating revenues, all revenues were reduced by 10%.

Economic Revenues

Since exchanging foreign currencies is freely done without restriction and due to unavailability of state determined shadow exchange rate, prices of imported and exported goods and their substitutes were not shadow priced. Locally produced goods and services were not shadow priced as well. Due to existence of partial unemployment in the

country, unskilled labors economic wage were reduced by 25%. Economic cost of land was increased to ID887000/ha, which represents the net profit obtained from growing agricultural crops. This value was estimated by calculating the profit of producing agricultural crops in second regime.

Indirect output were also introduced in the economic analysis as follows; Fuelwood. To calculate the amount of fuelwood produced by Plane trees, an equation was developed by Al-Jbouri (2007) to estimate weight of branches of *Platanus occidentali*s in Nineveh plantation.

$$Wb = (1.00174 + 0.00624\ dbh - 0.00006\ dbh^2)^{50}$$

Although the species is different and the stand structure and development will not be the same nor the Silvicultural treatments and their intensities, it was used to estimate annual production of fuelwood for plane tree after some modification. According to the above reference, the amount of fuelwood produced by a tree with 30cm dbh was estimated to be 561kg. This figure looks to be plausible for open-grown trees, for stand-grown trees, it seem to be exaggerated. Since all our trees are stand grown trees, the obtained figure was multiplied by 0.45. If the result is divided by 25 (tree age at rotation) the average annual production of plane trees of branches would be 10kg/tree. This figure was used to estimate amount of branches (fuelwood) produced in each pruning, thinning and final harvest. Table 3 presents the calculated amount of fuelwood produced each year and their values. The local price of ID40000/ton is implemented to estimate its value on site.

Carbon Sequestration. For the purpose of this work, it was assumed that each m³ of plane tree wood stores 0.5 ton of carbon. Ignoring the carbon that will be stored in branch and roots, the annual sequestered carbon was assumed to be half the MAI. With regard to the appropriate economic value, several prices were suggested in the literature. For the purpose of this work carbon economic price was set to $25/Ton which is equivalent to ID29250/ton (assuming the exchange rate is ID1170 for each dollar) (pearce *et al.* (2003).

Table (3): Amounts of fuelwood produced by each regime and their values.

Year	First Regime		Second Regime	
	Quantity Ton/ha	Value ID1000/ha	Quantity Ton/ha	Value ID 1000/ha
3	14	560	-	-
4	4	160	4	160
5	4	160	4	160
6	4	160	4	160
7	12	480	12	480
8	2	80	2	80
9	2	80	2	80
10	2	80	2	80
11	6	240	6	240
15	6.6	264	6.6	264
24	50.4	2016	50.4	2016

With respect to recreation and ecological values, pearce *et al.* (2003) suggested $5-10 /ha and $30/ha respectively. For the purpose of this work economic value of $7.5/ha (ID9000/ha) used for recreation and $30/ha (ID35000 /ha) for ecological value other than carbon sequestration. There are many other values that could be extracted from plane tree plantations such as using its leaves for medicine purposes, esthetic, oil extracted from converting branches to charcoal, etc. The economic value for these products were assumed $50 per ha/year (ID59000). The pollution that might occur due to using chemicals such as insecticides and fertilizers is one of the economic costs that the project incurs. No attempts, however, were made to value these costs and introduce them into calculation of the economic profitability.

Financial and Economic Criteria

In this work, criteria that are most frequently used in forest project analysis were employed. These criteria included Net Present value (NPV), benefit cost ratio (B/C), land expectation value (Le), and, internal rate of return (IRR). These criteria are calculated using the following formula,

$NPV = \sum [R_t / (1+i)^t] - \sum[C_t / (1+i)^t]$

$B/C = \{\sum [R_t / (1+i)^t]\} / \{ \sum [C_t / (1+i)^t] \}$

$Le = \{\sum (Rt - C_t) / (1 + i)^{n-t} \}/\{(1 + i)^n - 1\}$

While IRR is determined iteratively by calculating the discount rate (i) that equalize both sides of the following formula

$\sum [R_t / (1+i)^t] = \sum [C_t / (1+i)^t]$

Where NPV is the net present value, R_t is revenue received at time t , C_t is cost incurred at time t, t is time, i is discount rate, B/C is the benefit cost ratio, Se is the soil expectation value, and n is the rotation age.

Choosing appropriate discount rate is one of the problems confronted in feasibility analysis of forest projects. The discount rate used to calculate the financial criteria was 9%. This rate is used by state banks for compounding saving accounts. With absence of state determined economic discount rate same discount rate 9% was used for both analysis although it is believed that the economic discount rate expected to be less than financial one (Pearce, 1986). Since the early years of projects life bear most of the costs and bulk of the revenues occurs in the last year, the chosen discount rate is a real one rather than a nominal one (Gregersen, 1975).

RESULTES

Appendixes 4 and 5 demonstrate the cash flow tables for first and second regimes respectively. The revenues of the first regime were generated from four thinning, final cut, and salvage values. For the second regime, revenues were occurred from vegetable production at years 0 and 1, three thinning, final harvest, and salvage values. Table 4 presents the results of the financial analysis for both regimes. With respect to first regime, the IRR was 20.67% in real term. This means that this project will annually earn 20.67% on the invested capital. The NPV was ID22257/ha measured on current ID in addition to 8% interest rate. The B/C value was 2.92 which mean that each invested ID will earn ID2.92 measured in present value. Value of Le was ID25 324 000/ha. This means that the present value for perpetual rotation ages is ID25 324 000/ha. Values of the same respective criteria for the second regime were 21.43%, ID22 504 000 /ha, 2.45 and ID25 603 000/ha. These criteria indicate that both regimes are highly profitable. Comparing between the two regimes, producing vegetables slightly increased financial criteria values except for B/C ratio.

Appendixes 6 and 7 present the value flow table of the two considered regimes, with and without vegetable production respectively. Comparing these two tables with their correspondent cash flow table, one can notice that economic costs and revenues for both regimes exceed the financial costs and revenues. Comparing the costs and revenues of the two regimes, one can notice that producing vegetable requires more investment (relatively larger project) compared without producing vegetable. For first regime, values of IRR, NPV, and B/C ratio were 18.43%, ID19572000/ha and 2.45 respectively. For the second regime, values of same criteria were 18.64%, ID19504000/ha and 1.83 respectively. With respect to NPV, the edge that producing vegetable had in financial analysis reversed in economic analysis. The differences between the criteria values of the two regimes, however, were very small. There was a conflicting result with regard to which regime was more profitable. NPV, B/C ratio and Le were in favor of the first regime while IRR gave priority to the second regime. Second regime had more return in years 0 and 1 (revenues of vegetable) therefore it had more IRR. The profit of financial analysis outweighed the profit of economic analysis. This difference solely caused by low value for land used in financial analysis.

Table (4): Financial and economic return for each regime

Type of Project	Analysis	Real IRR (%)	NPV (ID1000/ha)	B/C ratio	Le (ID 1000/ha)
Financial Analysis	1st Regime	20.67	22257	2.92	25324
	2nd Regime	21.43	22504	2.45	25603
Economic Analysis	1st Regime	18.43	19572	1.99	33002
	2nd Regime	18.64	19504	1.83	32925

Table (5): Impact of some change in costs, revenues, and increasing rotation age on the economic return of each regime.

Project	Criteria	No Change	Cost *(1.1)	Cost *(1.2)	Cost*(1.1) + Revenue *(0.9)	Rotation Age 29
1st Regime Financial	IRR (%)	20.67	19.44	18.35	18.13	18.22
	NPV (ID 1000/ha/)	22 257	21 095	19 934	17 708	16 155
	B/C	2.92	2.65	2.43	2.38	2.27
	Le (ID 1000/ha)	25 324	24 024	22 725	19 215	19 335
2nd Regime Financial	IRR (%)	21.43	19.48	17.91	17.61	19.81
	NPV (ID 1000/ha/)	22 504	20 953	19 401	17 151	17 205
	B/C	2.45	2.23	2.04	2.01	2.08
	Le (ID 1000/ha)	25 603	23 863	22 123	18 590	19 615
1st Regime Economic	IRR (%)	18.43	16.89	15.57	14.75	16.55
	NPV (ID 1000/ha/)	19 572	17 603	15 633	12 834	13 810
	B/C	1.99	1.81	1.66	1.57	1.68
	le (ID 1000/ha)	33 002	31 861	30 719	27 419	26 900
2nd Regime Economic	IRR (%)	18.64	16.64	15.04	14.72	16.7
	NPV (ID 1000/ha/)	19 504	17 156	14 818	12 858	13 742
	B/C	1.83	1.66	1.53	1.51	1.57
	Le (ID 1000/ha)	32 925	31 355	29 786	26 493	26 822

Table (6): Minimum stumpage prices that make each regime financially and economically break-even (ID 1000 /m³).

Year	Original Price	Financial Analysis		Economic Analysis	
		First Regime	Second Regime	First Regime	Second Regime
3	140	43	-	56	-
7	257	79	75	103	96
11	374	115	109.5	150	142
15	433	133.7	126.8	137	164
24	550	169	161	220	209

Table (7): Minimum MAI and maximum land rent that make each alternative investment financially and economically break even.

Project	Financial Analysis		Economic Analysis	
	Minimum MAI (m³/ha/year)	Maximum Land Rent (ID 1000/ha/year)	Minimum MAI (m³/ha/year)	Maximum Land Rent (ID1000/ha/year)
First Regime	5.09	2068	6.6	2695
Second Regime	4.77	2091	6.18	2689

Sensitivity Analysis

Table 5 reveals the impact of increasing costs by 10% then by 20% and finally when simultaneously increasing costs by 10% and decreasing revenues by 10% on the values of economic criteria. Both investment alternatives remained profitable in both financial and economic analysis. Rotation age was initially set to 25 years. In this analysis, it was examined impact of extending rotation age to 29 years to obtain same yield and tree size. The changes in the cash flow table resulted from this alteration were, first, annual cost for years 25- 28 were equal to that of year 24. Second, revenue of final harvest was postponed from year 24 to year 28. Third, the weight of discounting the revenues of the final harvest is increased which will considerably reduce their discounted values. This analysis, implicitly assumes reduction of the MAI. Table 6 shows the values of economic criteria under this alteration. It indicates that the project remained profitable for both regimes in both financial and economic analysis

Break Even Analysis

For both regimes, prices were reduced by a small percentage, and then this percentage was continuously increased until each investment break even. Table 9 presents the original prices and the break even prices for both regimes. In both type of analysis, break even prices of second regime were slightly lower than those of the first one. Looking at the breakeven prices for both regime and analysis they look low enough to be considered safe. These values, however, were lower in financial analysis.

As stated earlier, the annual rent levied on irrigated agricultural land is very low, therefore, the maximum annual land cost that make each investment alternative break-even were calculated. Table 7 presents these values. In financial analysis, this investment could afford annual rent for each hectare ID2068 000 and ID2 091 000 for the first and second regime respectively. In economic analysis the correspondent values were ID2 695 000 and ID2 689 000 respectively. The results of this test indicate that this project is a safe investment.

The expected yield for plane tree plantations is another major source of uncertainty. The analysis of minimum MAI that makes each investment alternative break-even in both financial and economic analysis are given in table 7. Producing vegetable slightly reduced the required MAI to break even for both type of analysis. This analysis illustrates that the required MAI to break-even is within the reach and does not imply potential risk in both financial and economic aspects.

CONCLUSON AND RECOMENDATONS

Introducing plane tree plantations in the Kurdistan region will have many other advantages other than financial return. In addition to saving the foreign currency spent on importing the product, it will diversify the production which will in turn reduce the risk of investment for the growers. It will also reduce the negative aspects of monoculture associated with growing poplar plantations which is grown in relatively large area by growers and farmers, stimulate establishment of sawmills which will further contribute in the economic development of the region and will increase reliance on the locally produced raw materials.

The result of financial and economic analysis demonstrates that both regimes were feasible. The outcome of foreign currency flow expected to have a gigantic return of foreign currency since all revenues are considered saving of foreign currency while most costs are incurred in local currency. It should be understood that plantations have other values that were not included in the analysis due to difficulty in valuing them. Under the assumed prices, producing vegetable did not considerably boost both financial and economic return. This could be attributed, in part, to low prices assumed for vegetable in this analysis. The extensive work on the sensitivity analysis revealed that profitability status of both regimes did not reverse. All the break-even analysis displayed a fairly safe status for both regimes both in financial and economical aspects.

Prudent decisions are based on having good data. Data availability regarding plane tree species is very limited due to inexistence of plantations in the Duhok governorate, and scarcity of silvicultural research on this species. Consequently not much is known about the optimal intensity and timing of sivicultural treatments, growth and yield of this species. Despite that most of these treatments are separable component, they did not analyzed as such in this work. The reason was unavailability of data. Therefore, timing and intensity of Silvicultural treatments adopted in this work are no more than best judgment. They were included in order to have allowances for these indispensable activities.

Stumpage prices are another source of weakness in this analysis. Due to inexistence of market for plane tree wood in the area, the stumpage prices used in this analysis is considered conservative yet it bears a source of uncertainty, in addition to that, stumpage prices are size dependent. Predicting average size for plane trees is not a simple matter without having solid data. The other limitation of this work is yield. The assumed yield in this analysis was not exaggerated given all silvicultural treatments that were assumed to be implemented which have profound impact on quality and quantity of yield. Yet this figure is not based on research or actual plantation data and there is no concrete evidence that the adopted yield levels will be attained. The last restriction of this work is rotation age. The rotation age implemented in this work is a theoretical one. Optimal rotation age is bounded by price premium of large diameters, discount rate, and yield pattern. To arrive at financially and economically optimal rotation age, availability of these data are must. With accumulation of data and information through research optimal rotation age could be better predicted.

This work emphasizes that plane tree is a potential commercial species that should be seriously taken in consideration for future plantation establishment. Forest Agency should take the initiative to establish pilot projects of plane tree plantations and to provide extension and supervising services in addition to producing plane tree seedlings on large scale to meet demand. Research institutes should test impact of different Silvicultural strategies on the growth and yield of plane tree plantation. This will open a route to consider each silvicultural treatment as a separable component and come up with the optimal timing and intensity of each treatment. Research should also be extended to explore impact of silvicultural treatments on wood quality, wood seasoning, developing genetically improved stock that better resist insects and diseases attacks and have better yield, harvesting and marketing, and financial and economic optimal rotation age.

Establishing plantations on larger scale will have better profitability due to economic of scale. Plane trees have the property of growing from coppice. Growth from coppice is, in general, more rapid than from seedling. Therefore, project life could be extended to include subsequent coppice rotations. The costs and revenues structure of coppice rotation will differ from the first rotation. Cost establishment which is one of the major cost affects on the project profitability will be eliminated, while, weeding cost at early stage of coppice rotation will increase. In general, cost saving of coppice rotation outweighs its induced costs. It will be interesting to know impact of inclusion of coppice rotation on the profitability of this project.

Platanus occidentalis is an exotic species that have been successfully grown as ornamental plant in Duhok and as stands at Nineveh plantation in Mosul city. Research should also consider this species in order to obtain information with regard to growth, yield and wood properties of this species as well. This information could then be incorporated in the economic analysis to make a sound recommendations concerning the sites that best suite each species, or the superiority that might on species have over the other.

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شيانێن درافی و ئابوری نهالستانین جناری(*Platanus orientalis L.*) ل پارێزگەها دهوك

پوختە

چنار ئێك ژوان دارێن كو شين دبن بشێوەیەكێ سروشتی ل كوردستانا عێراقێ. دارێ ڤی جوری سالوخەتێن باش یێت هەین كو دشێن وێ بكار بینن د پێشەسازییا بەرهەمێن داری یێن باش،سەرەرای ڤێ چەندێ تا كو ڤێ گاڤێ گرنگی ب چاندنا وان ل نهالستانداندا نە دایە. ڤێ ڤەكولینێ دیار كر كو نهالستانێن چنار مفا دارن ژ لایێ دارایی و ئابوری ڤە و لبن هەمی رێنیشاندەرێن ئابوری یت بكارئینای دڤەكولینێ دا. ڤەكولینێن شروڤەكرنا هەستیاریێ دیار كر كو ڤی پروژەی چو مەترسی ل سەر نە بوون.

الجدوى المالية و الأقتصادية لمشاجر الجنار (*Platanus orientalis L.*) في محافظة دهوك

الخلاصة

الجنار هي أحدا أنواع الأشجار النامية بشكل طبيعي في العراق. خشب هذا النوع له خصائص جيدة لذلك يمكن تصنيع المنتجات الخشبية الجيدة منها و مع ذلك لم يستخدم هذا النوع في أنشاء المشاجر. لقد تم دراسة نمطين من الانتاج لمشاجر الجنار يتضمى النمط الأول انتاج الخضراوات اما النمط الثاني فبدون انتاج الخضراوات. في التحليل المالي تبين بأن النمط الثاني كان متفوقا قليلا تحت جميع المعايير الأقتصادية بأستثناء نسبة العوائد الى التكاليف. أما في التحليل الأقتصادي فأن جميع المعايير الأقتصادية أضهرت بأن النمط الأول كا ن متفوقا قليلا تحت جميع المعايير. نتائج تحليل الحساسية بينت بأن الأستثمار في أنشاء مشاجر الجنار مربحة و ليس فيه مخاطرة.

Appendix (1):- Cost of different inputs (ID/day).

		Abbreviation	Cost (ID 1000/day)
	Shovel	Sh	360
2	Tractor	T	160
3	Grader	G	360
4	Bulldozer	B	600
5	Labor	-	20
6	Pickup	P	50
7	Small Tractor	ST	150
8	Seedling	-	0.5
9	Lorry	L	130
10	Excavator	Ex	300

Appendix (2):- Output per hectare for labors and machines and their costs in addition to material costs for the first regime**.**

Activity			**Output in ha/day 1000 ID**		**Cost in ID/ha/day 1000 ID**			**Total 1000 ID**
		Year	**Labor**	**Machine**	**Labor**	**Machine**	**Material**	
1	Clearing up	0	-	2 (Sh)	-	180	-	180
2	Disposal of debris	0	0.5	4 (T)	32	40	-	72
3	Ripping	0	-	2 (B)		300	-	300
4	Land leveling	0	-	2 (G)		180	-	
				2 (B)		300		480
5	Cultivation disking twice	0	-	2.5 (T)	-	64	-	64
6	Ditching	0	1	2 (T)	16	80	-	96
7	marking blocks and furrows	0	1	-	16	-	-	16
8	Main canal	0	-	6 (Ex)	-	50	-	50
9	Road construction	0	-	5 (G)	-	72	-	72
10	Testing water level and hand ditching	0	0.5	-	32	-	-	32
11	Digging hole for planting	0	0.1[a]	-	160	-	-	160
12	Transport of seedling to the site	0	1	1 (L)	16	130	-	146
13	Planting	0	0.2 [b]	-	80	-	500	580
14	Building	0	-	-	-	-	-	47
15	Water pump.	0	-	-	-	55	-	55
16	Truck	0	-	-	-	89	-	89
	Total				**352**	**1540**	**500**	**2439**
17	Replacement of - Water Pump	5,10,15,20	-	-	-	49	-	49
	- Truck	10, 20	-	-	-	53	-	53
18	Fertilization - N	0 - 24	1.5	-	10	-	3	13
	- P	0, 7	1.5	-	10	-	6	16
19	Irrigation	0 - 24	1.5	-	10	-	-	260 [c]
20	Protection against insects and diseases	0 - 24	0.5	6 (H)	32	10	25	67
21	Pruning	1 - 10	0.2	-	80	-	100	180
22	Maintenance of							
	- Ditches	0 - 24	-	6 (Sh)	-	60	-	60
	- Roads	0 - 24	-	10 (G)	-	36	-	36
	- Truck	0 - 24	-	-	-	9	-	9
	- Water pump	0 - 24	-	-	-	6	-	6

	- Building	0 - 24	-	-	-	1	-	1
23	Wedding and cleaning ditches	0	0.06	-	266	-	-	266
		1	0.09	-	178	-	-	178
		2	0.14	-	114	-	-	114
		3	0.09	-	178	-		178
		4	0.14	-	114	-	-	114
		5	0.21	-	76	-	-	76
		6	0.30	-	53	-	-	53
		7	0.14	-	114	-	-	114
		8	0.21	-	76	-	-	76
		9 - 24	0.3	-	53	-	-	53
24	Cultivation	0-1	-	1.5 (St)	-	100	-	100
25	Replanting f	1	2	20 (L)	8	7	25	40
26	Tending and management	00 -24	-	-	-	-	-	32
			-	-	-	-	-	143 [I]
27	Land	0 - 24	-	-	-	-	-	12

Note:

a: Each labor digs 200 holes a day.
b: Each labor plant 200 seedling a day.
c: Number of irrigation per year is 26.
g: Mortality 5% first year, 50 seedlings.
f: Mortality 5% first year, 100 seedlings.
h: 20 day, cost 40000 per day, plus cost of transportation 30000 ID/day.
I: Social security cost equal to 12%.

Appendix (3):- Output per hectare for labors and machines and their costs in addition to material costs for the

	Activity	Year	Output in ha/day 1000 ID		Cost in ID/ha/day 1000 ID			Total 1000 ID
			Labor	Machine	Labor	Machine	Material	
1	Clearing up	0	-	2 (Sh)	-	180	-	180
2	Disposal of debris	0	0.5	4 (T)	32	40		72
3	Ripping	0	-	2 (B)	-	300	-	300
4	Land leveling	0	-	2 (G) 2 (B)		180 300	-	480
5	Cultivation disking twice	0	-	2.5 (T)	-	64	-	64
6	Ditching	0	2	4 (T)	8	40	-	48
7	marking blocks and furrows	0	2	-	8	-	-	8
8	Main canal	0	-	6 (Ex)	-	50	-	50
9	Road construction	0	-	5 (G)	-	72	-	72
10	Testing water level and hand ditching	0	0.75	-	21	-	-	21
11	Digging hole for planting	0	0.2[a]	-	80	-	-	80
12	Transport of seedling to the site	0	2	2 (L)	8	75	-	83
13	Planting	0	0.4[b]	-	40	-	250	290
14	Building	0	-	-	-	-	-	47
15	Water pump.	0	-	-	-	55	-	55
16	Truck	0	-	-	-	89	-	89
Total					**197**	**1445**	**250**	**1939**
17	Replacement of - Water pump	5, 10, 15, 20	-	-	-	49	-	49
	- Truck	10, 20	-	-		53	-	53
18	Fertilization - N	0, 1	1	-	16	-	6	22
		2 - 24	1.5	-	10	-	3	13
	- P	0, 7	1.5	-	10	-	6	16
19	Vegetables	0, 1	-	-	-	-	-	1920
20	Irrigation	0 - 24	1.5	-	10	-	-	260[c]
21	Protection against insects and diseases	0 - 1	0.25	6 (H)	64	10	50	124
		2 - 24	0.5		32	10	25	67
22	Pruning	1 - 10	0.2	-	100	-	100	200
23	Maintenance of -- Ditches							
	- Roads	0 - 25	-	6 (Sh)	-	60	-	60
	- Truck	0 - 25	-	10 (G)	-	36	-	36
	- Water pump	0 - 24	-	-	-	9	-	9
	- Building	0 - 24	-	-	-	6	-	6
		0 - 24	-	-	-	1	-	1
24	Weeding and cleaning ditches	0	0.03	-	533	-	-	533
		1	0.04	-	400	-	-	400
		2	0.07	-	228	-	-	228
		3	0.09	-	178	-		178
		4	0.14	-	114	-	-	114
		5	0.21	-	76	-	-	76
		6	0.30	-	53	-	-	53
		7	0.14	-	114	-	-	114
		8	0.21	-	76	-	-	76
		9 -24	0.3	-	53	-	-	53
25	Cultivation	0, 1	-	1.5 (St)	-	100		100
26	Replanting g	1	4	40 (L)	4	3	13	20
27	Tending and management	0	20[h]					32
		0 -24						143[i]
28	Land	0 - 24	-	-	-	-	-	12

Appendix (4): Cash flow table of first regime.

Year	Capital Cost	Current Cost	Total Cost	Adjusted Total Cost	Revenue	Net Cash Flow	Discount Rate	Total Discount Cost	Total Discount Revenue	Current Cash Flow
0	1687	1630	3317	3353.98	0	-3353.98	1	3353.98	0	-3353.98
1	200	905	1105	1117.32	0	-1117.32	0.917431	1025.06	0	-1025.06
2	100	801	901	911.04	0	-911.046	0.84168	766.80	0	-766.80
3	100	865	965	975.75	693	-282.76	0.772183	753.46	535.1232	-218.34
4	100	801	901	911.042	0	-911.046	0.708425	645.40	0	-645.40
5	149	763	912	922.16	0	-922.169	0.649931	599.34	0	-599.34
6	100	740	840	849.36	0	-849.366	0.596267	506.44	0	-506.44
7	100	817	917	927.22	11449.8	10522.58	0.547034	507.22	6263.433	5756.20
8	100	763	863	872.62	0	-872.622	0.501866	437.93	0	-437.94
9	100	740	840	849.36	0	-849.366	0.460428	391.07	0	-391.07
10	202	740	942	952.50	0	-952.503	0.422411	402.34	0	-402.34
11	0	660	660	667.35	14810.4	14143.04	0.387533	258.62	5739.517	5480.89
12	0	660	660	667.35	0	-667.359	0.355535	237.26	0	-237.26
13	0	660	660	667.35	0	-667.359	0.326179	217.67	0	-217.67
14	0	660	660	667.35	0	-667.359	0.299246	199.70	0	-199.70
15	49	660	709	716.90	15003.9	14286.99	0.274538	196.81	4119.141	3922.32
16	0	660	660	667.35	0	-667.359	0.25187	168.08	0	-168.08
17	0	660	660	667.35	0	-667.359	0.231073	154.20	0	-154.20
18	0	660	660	667.35	0	-667.359	0.211994	141.47	0	-141.47
19	0	660	660	667.35	0	-667.359	0.19449	129.79	0	-129.79
20	102	660	762	770.49	0	-770.496	0.178431	137.48	0	-137.48
21	0	660	660	667.35	0	-667.359	0.163698	109.24	0	-109.24
22	0	660	660	667.35	0	-667.359	0.150182	100.22	0	-100.22
23	0	660	660	667.35	0	-667.359	0.137781	91.94	0	-91.94
24	0	660	660	667.35	136199.7	135532.3	0.126405	84.35	17216.32	17131.96
								11616.03	33873.53	22257.5

Appendix (5): Cash flow of second regime

Year	Capital Cost	Current Cost	Total Cost	Adjusted Total Cost	Revenue	Net Cash Flow	Discount Rate	Total Discount Cost	Total Discount Revenue	Current Cash Flow
0	1592	3478	5070	5126.53	2700	-2426.53	1	5126.53	2700	-2426.53
1	200	3093	3293	3329.71	2160	-1169.72	0.917431	3054.78	1981.651	-1073.13
2	100	915	1015	1026.31	0	-1026.32	0.84168	863.830	0	-863.83
3	100	865	965	975.75	0	-975.76	0.772183	753.46	0	-753.46
4	100	801	901	911.04	0	-911.04	0.708425	645.40	0	-645.40
5	149	763	912	922.16	0	-922.16	0.649931	599.34	0	-599.34
6	100	740	840	849.36	0	-849.36	0.596267	506.44	0	-506.44
7	100	817	917	927.22	11449.8	10522.58	0.547034	507.22	6263.433	5756.20
8	100	763	863	872.62	0	-872.62	0.501866	437.93	0	-437.94
9	100	740	840	849.36	0	-849.36	0.460428	391.07	0	-391.07
10	202	740	942	952.50	0	-952.50	0.422411	402.34	0	-402.34
11	0	660	660	667.35	14810.4	14143.04	0.387533	258.62	5739.517	5480.89
12	0	660	660	667.35	0	-667.35	0.355535	237.26	0	-237.269
13	0	660	660	667.35	0	-667.35	0.326179	217.67	0	-217.67
14	0	660	660	667.35	0	-667.35	0.299246	199.70	0	-199.70
15	49	660	709	716.90	15003.9	14286.99	0.274538	196.81	4119.141	3922.32
16	0	660	660	667.35	0	-667.35	0.25187	168.08	0	-168.08
17	0	660	660	667.35	0	-667.35	0.231073	154.20	0	-154.20
18	0	660	660	667.35	0	-667.35	0.211994	141.47	0	-141.47
19	0	660	660	667.35	0	-667.3	0.19449	129.79	0	-129.79
20	102	660	762	770.49	0	-770.49	0.178431	137.48	0	-137.48
21	0	660	660	667.35	0	-667.35	0.163698	109.24	0	-109.24
22	0	660	660	667.35	0	-667.35	0.150182	100.22	0	-100.22
23	0	660	660	667.35	0	-667.35	0.137781	91.94	0	-91.94
24	0	660	660	667.35	136199.7	135532.3	0.126405	84.35	17216.32	17131.96
								15515.32	38020.06	22504.74

Appendix (6): Value flow for first regime.

Year	Capital Cost	Current Cost	Total Cost	Adjusted Total Cost	Revenue	Net Cash Flow	Discount Rate	Total Discount Cost	Total Discount Revenue	Current Cash Flow
0	1687	2287	3974	4018.31	360	-3658.31	1	4018.31	360	-3658.31
1	200	1630	1830	1850.40	360	-1490.4	0.917431	1697.61	330.27	-1367.34
2	100	1545	1645	1663.34	360	-1303.34	0.84168	1400.00	303.00	-1097
3	100	1592	1692	1710.86	1613	-97.8658	0.772183	1321.10	1245.53	-75.57
4	100	1545	1645	1663.34	520	-1143.34	0.708425	1178.35	368.38	-809.97
5	149	1507	1656	1674.46	520	-1154.46	0.649931	1088.28	337.96	-750.32
6	100	1499	1599	1616.82	520	-1096.83	0.596267	964.06	310.05	-654.00
7	100	1559	1659	1677.49	12289.8	10612.3	0.547034	917.64	6722.94	5805.29
8	100	1516	1616	1634.01	440	-1194.02	0.501866	820.05	220.82	-599.23
9	100	1499	1599	1616.82	440	-1176.83	0.460428	744.43	202.58	-541.84
10	202	1499	1701	1719.96	440	-1279.97	0.422411	726.53	185.86	-540.67
11	0	1439	1439	1455.04	15410.4	13955.36	0.387533	563.87	5972.03	5408.15
12	0	1439	1439	1455.04	360	-1095.04	0.355535	517.31	127.99	-389.32
13	0	1439	1439	1455.04	360	-1095.04	0.326179	474.60	117.4243	-357.18
14	0	1439	1439	1455.04	360	-1095.04	0.299246	435.41	107.72	-327.68
15	49	1439	1488	1504.59	15627.9	14123.31	0.274538	413.06	4290.45	3877.38
16	0	1439	1439	1455.04	360	-1095.04	0.25187	366.48	90.67	-275.80
17	0	1439	1439	1455.04	360	-1095.04	0.231073	336.22	83.18	-253.03
18	0	1439	1439	1455.04	360	-1095.04	0.211994	308.46	76.31	-232.14
19	0	1439	1439	1455.04	360	-1095.04	0.19449	282.99	70.01	-212.97
20	102	1439	1541	1558.18	360	-1198.18	0.178431	278.02	64.23	-213.79
21	0	1439	1439	1455.04	360	-1095.04	0.163698	238.18	58.93	-179.25
22	0	1439	1439	1455.04	360	-1095.04	0.150182	218.52	54.06	-164.45
23	0	1439	1439	1455.04	360	-1095.04	0.137781	200.47	49.60	-150.87
24	0	1439	1439	1455.04	138575.7	137120.7	0.126405	183.92	17516.65	17332.73
								19693.99	39266.74	19572.75

Appendix (7): Value flow for second regime.

Year	Capital Cost	Current Cost	Total Cost	Adjusted Total Cost	Revenue	Net Cash Flow	Discount Rate	Total Discount Cost	Total Discount Revenue	Current Cash Flow
0	1592	4097	5689	5752.43	3060	-2692.43	1	5752.43	3060	-2692.43
1	200	3754	3954	3998.08	2520	-1478.09	0.917431	3667.97	2311.92	-1356.04
2	100	1630	1730	1749.29	360	-1389.29	0.84168	1472.34	303.00	-1169.34
3	100	1592	1692	1710.86	360	-1350.87	0.772183	1321.10	277.98	-1043.12
4	100	1545	1645	1663.34	520	-1143.34	0.708425	1178.35	368.38	-809.97
5	149	1516	1665	1683.56	520	-1163.56	0.649931	1094.20	337.9643	-756.23
6	100	1499	1599	1616.82	520	-1096.83	0.596267	964.06	310.05	-654.00
7	100	1559	1659	1677.49	12289.8	10612.3	0.547034	917.64	6722.94	5805.29
8	100	1516	1616	1634.01	440	-1194.02	0.501866	820.05	220.82	-599.23
9	100	1499	1599	1616.82	440	-1176.83	0.460428	744.43	202.58	-541.84
10	202	1499	1701	1719.96	440	-1279.97	0.422411	726.53	185.86	-540.67
11	0	1439	1439	1455.04	15410.4	13955.36	0.387533	563.87	5972.03	5408.15
12	0	1439	1439	1455.04	360	-1095.04	0.355535	517.31	127.99	-389.32
13	0	1439	1439	1455.04	360	-1095.04	0.326179	474.60	117.42	-357.18
14	0	1439	1439	1455.04	360	-1095.04	0.299246	435.41	107.72	-327.68
15	49	1439	1488	1504.59	15627.9	14123.31	0.274538	413.06	4290.45	3877.38
16	0	1439	1439	1455.04	360	-1095.04	0.25187	366.48	90.67	-275.80
17	0	1439	1439	1455.04	360	-1095.04	0.231073	336.22	83.18	-253.03
18	0	1439	1439	1455.04	360	-1095.04	0.211994	308.46	76.31	-232.14
19	0	1439	1439	1455.04	360	-1095.04	0.19449	282.99	70.01	-212.97
20	102	1439	1541	1558.18	360	-1198.18	0.178431	278.028	64.23	-213.79
21	0	1439	1439	1455.04	360	-1095.04	0.163698	238.18	58.93	-179.25
22	0	1439	1439	1455.04	360	-1095.04	0.150182	218.52	54.06	-164.45
23	0	1439	1439	1455.04	360	-1095.04	0.137781	200.47	49.60	-150.87
24	0	1439	1439	1455.04	138575.7	137120.7	0.126405	183.92	17516.65	17332.73
								23476.72	42980.85	19504.13

THE RELATIONSHIPS BETWEEN GEO-TECHANICAL PROPERTIES AND CRACKS OF VERTISOLS IN DOHUK GOVERNORATE

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ABSTRACT

Vertisols covered vast areas in Duhok governorate, and there is no comprehensive study about geo- technical properties in it, that are closely related with cracks in vertisols, therefore is very important to study this relation, depending on the statistical analysis in order to give clear idea about these properties that are consider very important in the field of agriculture and engineering to achieve this objective this study was conducted. Twenty seven surface and subsurface soil samples representing vertisols in Dohuk governorate (Doban, Sulaivani and Sendi plains) were obtained. Highly calcareous study soils. Soil physical, chemical and geo- technical properties were determined according to the standard methods. The results are displayed for linear shrinkage in vertisols of sulaivani plain were larger than the linear shrinkage values in doban and sendi plain whereas the smallest values were found in vertisols of sendi plain. Generally found inverse relationship between linear shrinkage values and carbonate (Total and Active) in vertisols of the study areas. The stepwise multiple linear regression relationship established between width of crack and (Total carbonate, Sand fraction, Iron oxides and Electrical conductivity) properties. There is a highly significant correlation between width of cracks and each of previous soil properties (Sig. = 0.000003). The statistical analysis results indicated that the total and active carbonate effected on the depth of cracks profoundly (r^2 = 0.83) and this relationship was very high significant (Sig. = 0.0001). The results also showed great conformity between observed and predicted swelling percentage in vertisols of study areas. The best fit of plasticity index with total and active clay is a second degree polynomial (r^2 = 0.978). Based on clay activity values the study soils were classified as inactive clays (A.C. < 0.70). Geotechnical properties analyses are indicated that the consistency index values decreased with depth in all pedons except pedon (9) and this may be due to concentrated organic matter in the surface layer of the soil and decreasing with depth. Can be concluded the study soils exhibit high potential to swell and shrinkage and highly significant correlation of swelling percent with clay activity, active carbonate, organic matter, sand and EC.

KEY WORDS: Vertisols, cracks, geotechnical properties, clay activity, linear shrinkage percentage, plastic limit

INTRODUCTION

Vertisols are typically dark colored soils and characterized by a high percentage of clay content dominated by a smectite group of minerals. Dominance of smectite group of minerals leads to expansion and shrinkage on wetting and drying respectively. Low infiltration rate, high plasticity and stickiness, low organic matter, high cation exchange capacity, calcareous nature, and alkaline reaction are some of the properties associated with these soils, (Stewart, 1988). Data concerning soil geo-technical properties are required by civil and agricultural engineers. These data are sought for the planning and construction of different projects, including agricultural purposes (Earth dam, construction, settling of structure, compaction of soil, etc), (Smith et al., 1985). There is a close correlation between liquid limit and CEC, as well as a good relationships were found between Atterberg limits and chemical and physical properties of various American soils containing mainly 2:1 clay minerals on the other hand, there are multiple correlations between liquid limit, and plastic limit and plasticity index three soil properties (Percentage organic carbon, percentage clay and percentage montmorillonite in the clay separate) for soils in Illinois (Odell et al., 1960). The soils exhibiting high shrinkage with large amounts of montmorillonite present in clay fraction, shrinkage is usually related to expansible mineral content (Green-kelly, 1974). Large cracking occurs in clayey soil and because the large cracks are vertical, the vertical shrinkage is assumed to be larger than the horizontal shrinkage. On the other hand soil cracking is closely related with soil shrinkage and accompanies it. Clay is a single shrink-swell component of soil. Liquid limit is highly correlated with CEC and hygroscopic water. A

significant relationship exists between liquid limit and clay percentage and to lesser extent with ESP and organic matter, as well as the amount of organic matter in soil increases its liquid and plastic limits, (Smith et al., 1985). Terra-rossa soils (Red soils) are highly leached status have predominantly kaolinitic clay fraction leading to low specific surface area. Consequently these soils have low liquid limits (35-45) and plastic limits (21-29) despite clay content. Terra-rossa soils (Red soils) of drier areas show appreciable high liquid and plastic limits (55 and 33 respectively). This is due to the higher specific surface areas because of appreciable amounts of montmorillonite attributed to drier conditions, (Chertkov, 2007). McCormack and Wilding, (1975) are observed that plasticity index (PI) and Atterberg limits are often related to clay content, whereas Gray and Allbrook, (2002) have shown that clay minerals rather than clay content has greater influence on the plasticity index and Atterberg limit. A linear relationship between clay minerals of naturally occurring clays and liquid limit was found by Schmitz et al. (2004). The ratio of CEC to clay content is commonly used indicator of clay activity, has been useful predictor of soil water retention in range of soils, Pachepsky and Rawls (1999).Variation in CEC and exchange cations has also been found to directly influence shrink/swell capacity, McGarry (1996). Clay activity alone is a poor predictor of shrink/swell potential and high CEC/Clay (>30 cmolec.kg-1 clay) values in vertisols indicate the presence of high charge (2:1) layer silicates such as smectite especially when organic matter content is low, Vertisols has a high plastic index (PI >17) with a wide range of clay contents (37-73%) and CEC (22-74 cmolec.kg-1) (Chinn and Pillai, 2008). On the other hand Schmitz et al., (2004) concluded that smectite percent alone was a poor predictor of liquid limit.

The objective of present research forms a part of investigation to identification the influencing of geo-technical properties on cracks as well as correlative information of geo-technical properties with shrinkig and swelling in vertisols of Dohuk governorate (Doban, Sulaivani and Sendi Plains).

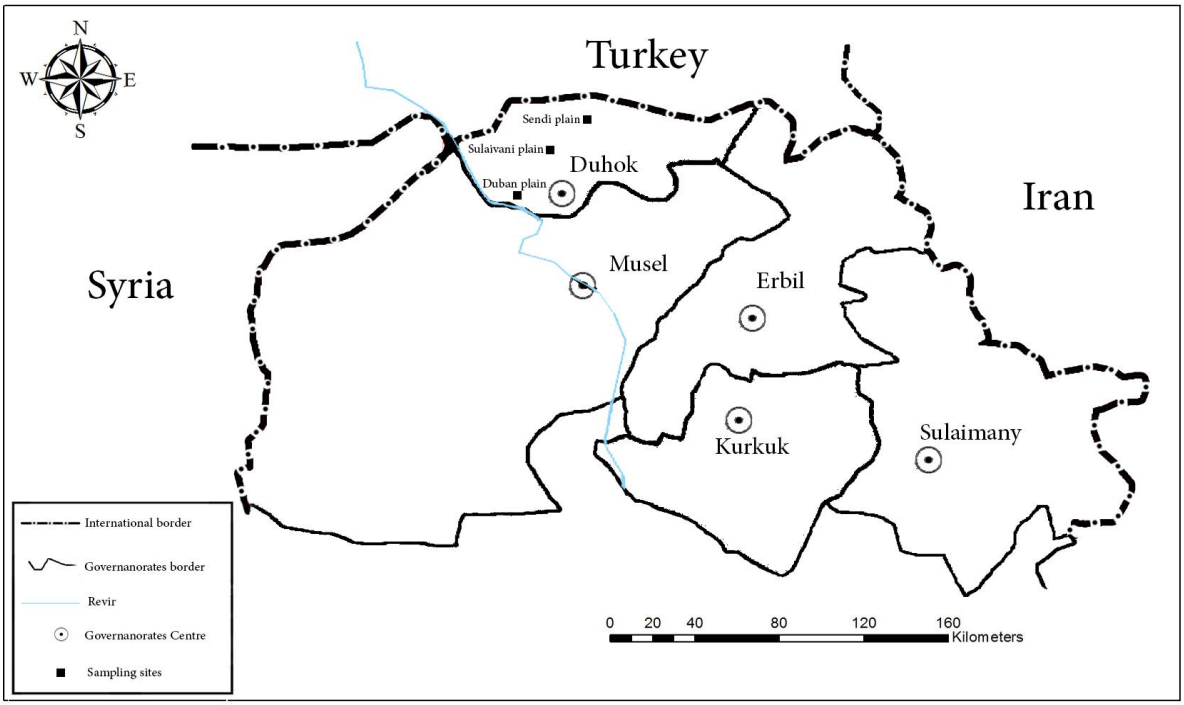

Fig. (1): Location map showing the study areas.

METHODS AND MATERIALS

Twenty seven surface and subsurface soil samples representing vertisols in Dohuk governorate (Doban, Sulaivani and Sendi plains) were obtained (Fig. 1). Study soils are highly calcareous and classified according to US soil classification system as vertisols order (Soil survey staff, 2006). Soil moisture content was determined by gravimetric method according to Richards (1954). Particle size distribution was performed by hydrometer, (Klute et al., 1986).

Soil bulk density was measured by core method as described by, Blake and Hartge (1986). Particle density was determined by pycnometer as described by, ASTMD854 (1993). The pH and EC were measured by PH-meter model HI8417-HI8519 and EC-meter model HI 9635 respectively according to Jackson (1973). Exchangeable cations were determined according to Page et al., (1982). CEC measured according to Polemio and Rhoads (1977). Organic matter was estimated by wet oxidation method, (Walkley and Black, 1965). Total carbonate was measured by calcimeter, (Loeppert and Suarez, 1996) and active carbonate was estimated by Ammonium oxalate, (Kozhekov and Yakkovleva, 1977). Free iron oxides were measured by Na-DCB (Sodium Dithionite-Citrate-Bicarbonate) method as described by Mehra and Jackson (1960) (Table, 1 and 2). Liquid limit, Plastic limit and plasticity index were determined according to, ASTMD423, 424 (1993). Percent of linear shrinkage was measured according to BSI377 TEST NO. (1975). Liquid index, shrinkage percentage, swelling percentage, and consistency index were determined according to the methods as described by AL-Hamad, (1995) (Table, 3).

Table (1): Chemical properties of soil samples

No. of sample	Depth of sample	Location	No. of Pedon	EC ds.m^{-1}	PH	Exchangeable cations cmol.kg^{-1} Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Fr. Fe_2o_3 gm .Kg^{-1}	O.M. gm .Kg^{-1}	Total $CaCO_3$ gm .Kg^{-1}	Act$CaCO_3$ gm .Kg^{-1}	Act$CaCO_3$ / Tot$CaCO_3$	CEC cmol.Kg^{-1}	ESP
1	0-10			0.63	7.92	29.6	7.2	2.7	0.43	8.6	13.2	111.8	45	0.4	40.26	6.7
2	10-30		1	0.63	7.92	26	13.2	0.78	0.29	7.3	11.6	132.4	35	0.26	41.32	1.88
3	30-40			0.54	7.9	30.4	10	0.6	0.21	8.1	11.1	139.8	30	1.21	42.27	1.41
4	0-10			0.59	7.73	15.2	4.8	0.89	0.42	8.9	12.1	170.7	65	0.38	21.71	4.09
5	10-40		2	0.54	7.79	22	4	1.19	0.24	8.5	7.4	184	60	0.32	28.12	4.23
6	40-60	Doban plain		0.64	7.78	18.4	5.2	0.8	0.16	8	8.4	238.4	50	0.2	26.78	2.98
7	10-0			0.38	7.76	12.8	3.2	0.67	0.47	7.2	14.3	181	50	0.27	17.69	3.78
8	o -301		3	0.51	7.78	20	5.2	1.26	0.38	7.3	12.1	216.3	75	0.34	27.73	4.54
9	40-30			0.57	7.76	20.4	4	1.17	0.26	8.7	9	219.3	40	0.18	27.35	4.27
10	0-15			0.56	7.9	26	2.4	1.06	0.45	6.2	17.4	220.8	55	0.24	31.08	3.41
11	15-35		4	0.54	7.78	24	4	0.34	0.37	6.9	9	184	65	0.35	30.6	4.37
12	35-55			0.51	7.96	24.4	4.4	1.11	0.28	7.1	9.5	179.5	60	0.33	31.82	3.48
13	0-10			0.55	7.61	20	3.2	0.56	0.36	7.2	16.4	275.2	55	0.19	24.96	2.24
14	10 - 35	Sulaivani plain	5	0.52	7.75	21.6	4.4	0.58	0.31	7	11.6	276.7	55	0.19	27.73	2.09
15	35-50			0.46	7.86	24	6.4	0.54	0.25	7.4	10.6	285.5	45	0.15	31,75	1.7
16	0-20			0.5	8.12	21.2	5.6	1.08	0.44	7.4	21.2	287	45	0.15	29.46	3.66
17	20-40		6	0.42	8.08	22	4.8	0.95	0.34	8	18	272.3	35	0.12	28.69	3.31
18	40-55			0.5	7.91	22.8	5.6	1.15	0.23	7.2	10	154.5	45	0.29	30.6	3.75
19	0-15			0.54	7.86	22	6	0.75	0.39	5.2	16.9	228.1	50	0.21	29.84	2.51
20	15-40		7	0.45	8.08	20.8	5.2	0.76	0.3	5.5	17.4	223.7	55	0.24	28.02	2.71
21	40-50			0.44	8.04	20.4	6	0.81	0.25	4.8	18.5	222.2	55	0.24	28.5	2.84
22	0-10			0.72	8.08	20.8	6	0.85	0.23	5.7	14.3	247.2	55	0.22	28.69	2.96
23	10 - 30		8	0.44	8	21.2	5.6	1.06	0.44	6.8	13.7	198.7	55	0.27	29.65	3.57
24	30-45	Sendi plain		0.49	7.98	20	5.6	0.88	0.3	8.3	11.6	220.8	60	0.27	27.73	3.17
25	0-10			0.51	7.85	20.8	4	0.8	0.46	8.3	13.2	203.1	65	0.32	26.78	2.98
26	10 - 35		9	0.46	7.86	23.2	4	0.88	0.35	8.2	7.9	217.8	50	0.22	29.36	2.99
27	35-50			0.47	7.97	22	4.4	0.84	0.28	8.3	6.8	232.5	65	0.27	28.02	2.99

Table (2): Some physical properties of soil samples

No. of sample	No. of pedon	Location	Depth of crack cm	Width of crack cm	Particle size distribution g.kg^{-1}			Soil texture	Bulk Density Mg.m^{-3}	Porosity (f) %
					Clay	Silt	Sand			
1					473.7	390	136.3	Clay	1.49	44
2	1		30	4	473.7	390	136.3	Clay	1.57	41
3					473.7	365	161.3	Clay	1.53	43
4		Doban Plain			500	480	20	Silty clay	1.32	51
5	2		50	2	375	555	70	Silty clay loam	1.77	47
6					563.7	365	71.3	Clay	1.54	42
7					388.7	490	121.3	Loamy silty clay	1.59	40
8	3		35	7	400	555	45	Loamy silty clay	1.68	37
9					438.7	440	121.3	Silty clay	1.68	37
10					363.7	525	111.3	Silty clay loam	1.5	44
11	4		45	8	363.7	465	171.3	Silty clay loam	1.82	45
12					388.7	440	171.3	Silty clay loam	1.79	44
13		Sulaivani Plain			413	515	72	Silty clay loam	1.42	47
14	5		45	10	585	395	20	Clay	1.44	46
15					488.7	440	71.3	Silty clay	1.46	45
16					363.7	525	111.3	Silty clay loam	1.36	49
17	6		40	6	410	520	70	Silty clay	1.54	42
18					438.7	450	111.3	Silty clay	1.62	39
19					395	385	220	Clay loam	1.46	45
20	7		45	13	378.7	425	196.3	Silty clay loam	1.59	40
21					453.7	405	146.3	Silty clay	1.61	40
22		Sendi Plain			413.7	440	146.3	Silty clay	1.4	48
23	8		40	9	570	335	95	Clay	1.48	45
24					403.7	425	171.3	Silty clay	1.72	36
25					320	485	195	Silty clay	1.58	41
26	**9**		45	11	370	460	170	Silty clay loam	1.5	44
27					363.7	490	146.3	Silty clay loam	1.52	43

RESULTS AND DISCUSSION

The results are displayed for linear shrinkage in vertisols of sulaivani plain were larger than the linear shrinkage values in doban and sendi plain whereas the smallest values were found in vertisols of sendi plain. Generally found reversible relationship between linear shrinkage values and carbonates (Total and Active) in vertisols of study areas (Table, 1 and 3) Depending on the statistical analysis with using weighted estimation regression is explain highly correlation of linear shrinkage with clay activity, Iron oxides and sand percentage (R^2 = 0.66), this relationship was very high significant (Sig.= 0.0001) (Fig.2). The results show good efficiency for predicting the value of linear shrinkage depending on the following weighted estimation regression equation in conditions of studysoils:

Predict. Weighted linear shrinkage = 0.838158+1.878212Active clay-0.002864Sand +0.02365 Fe_2O_3

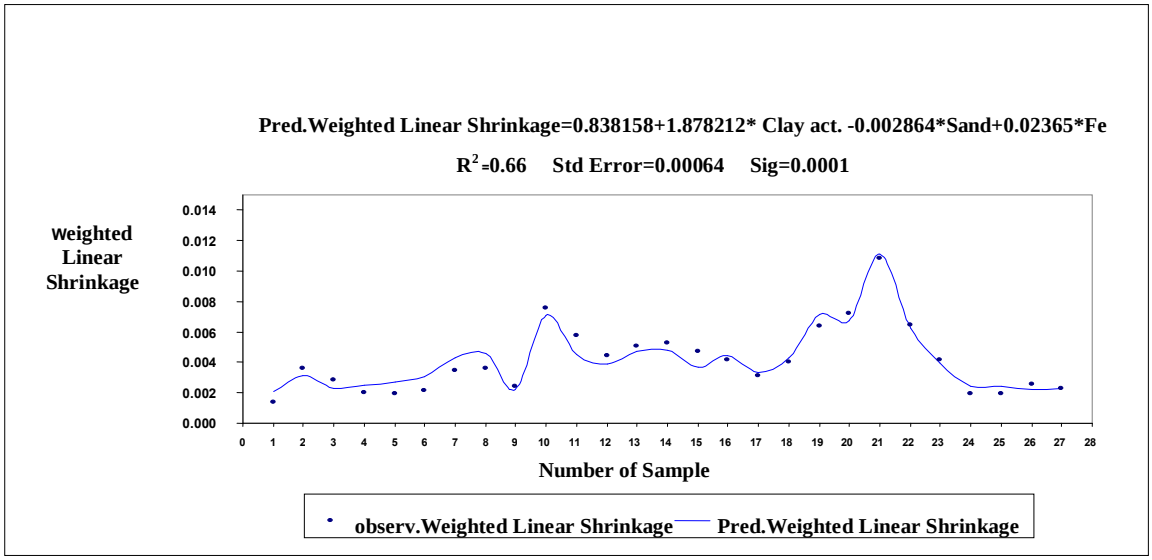

Fig. (2): Effect of (Clay activity, Sand and Iron Oxides) on weighted linear shrinkage with using weighted estimation regression equation.

Table (3): Geotechnical properties of soil samples

Sample	Depth cm	Region	Pedon	C. A.	L.S.P.%	L.I.Ø Init.	L.I. Ø sat.	Ø sat. %	Sh.P.R. %	Ø Init. %	C.I. %	Sw.P.R.%	L.L. %	P.L. %	L.Sh.	P.I. %
1	0-10			0.35	7	-1.05	0.22	29	29.07	7.4	2.05	40.99	42	25.2	0.9	16.8
2	10-30		1	0.32	10	-0.9	0.07	26	34.4	11.1	1.9	52.46	40	24.8	1.4	15.2
3	30-40			0.34	11	-0.89	0.2	28	30.04	10	1.89	42.94	41	24.6	1.5	16.4
4	0 - 10	Doban Plain		0.40	10	-0.81	0.75	39	21.19	7.4	1.81	26.88	44	23.8	1.4	20.2
5	10-40		2	0.43	9	-1.12	0.5	33	27.52	6.6	2.12	37.98	41	24.8	1.2	16.2
6	40-60			0.39	8	-0.75	0.15	27	36.72	6.8	1.75	58.04	46	23.6	1.1	22.4
7	0-10			0.50	13	-0.62	0.35	25	27	5.9	1.68	37.1	38.5	18.1	1.3	19.4
8	10-30		3	0.48	12	-0.56	0.23	22	30.8	6.3	1.55	44.6	36.7	17.4	1.4	19.5
9	30-40			0.40	10	-0.59	0.27	22	35.1	6.6	1.61	54.1	35.1	17.2	1.6	17.7
10	0-15			0.54	13	-0.9	0.22	29	25.98	6.6	1.9	35.1	44.5	24.6	1.8	20
11	15-35		4	0.52	14	-0.7	0.31	31	27.52	11.7	1.7	37.98	44	25	1.9	19
12	35-55			0.46	12	-0.53	0.33	29	22.69	13.3	1.53	29.35	41	22.9	1.6	18.1
13	0-10			0.51	11	-0.96	0.21	33	28.8	8	1.96	39.1	49.8	28.5	1.9	21.3
14	10 -35	Sulaivani plain	5	0.37	13	-0.79	0.23	32	25.6	9.5	1.79	34.5	48.5	26.8	1.8	21.7
15	35-50			0.37	15	-0.85	0.28	31	26.4	10	1.85	35.9	44.2	25.8	1.9	18.4
16	0-20			0.59	8	-0.81	0.49	36	29.4	7.6	1.81	41.1	47	25.3	1.7	21.7
17	20-40		6	0.46	10	-0.83	0.11	27	31.1	9.1	1.83	45.2	43.8	24.9	1.6	18.9
18	40-55			0.49	13	-0.62	0.03	24	33.2	10	1.62	49.7	45	23.5	1.5	21.5
19	0-15			0.36	7	-1.11	0.74	31	17.53	4.3	2.11	21.26	34.6	20.3	0.9	14.3
20	15-40		7	0.38	9	-0.91	0.34	25	23.55	6.9	1.91	30.63	34.5	20.1	1.2	14.4
21	40-50			0.37	9	-0.82	0.22	25	19.25	7.4	1.82	23.84	38.1	21.3	1.2	16.8
22	0-10			0.32	9	-1.04	1.11	35	26.7	6.1	2.04	36.5	33.5	20.1	1.2	13.4
23	10-30	Sendi plain	8	0.27	8	-0.81	0.73	31	21.9	6.7	1.81	28	35.2	19.5	1.3	15.7
24	30-45			0.45	11	-0.65	0.1	21	24.4	7.1	1.65	32.3	37.3	19	1.1	18.3
25	0-10			0.48	8	-1.12	0.11	26	20.6	6.8	2.12	26	39.7	24.2	1.1	15.5
26	10 -35		9	0.36	6	-1.33	0.27	29	21.9	7.3	2.33	28	38.8	25.3	1.4	13.5
27	35-50			0.36	12	-1.35	0.14	28	23.4	8	2.35	30.5	39.5	26.1	1.3	13.4

C. A.= Clay activity	**C.I.= Consistency Index**
L.S.P.= Linear shrinkage percentage	**Sw.P.R.=Swelling percentage ratio**
L.I.Ø Init.= Liquidity Index(Initial moisture content)	**L.L.= Liquid limit**
L.I. Ø sat.= Liquidity Index(Saturation moisture content)	**P.L.= Plastic limit**
Ø sat.%=Saturation moisture content	**L.Sh.= Linear shrinkage**
Sh.P.R.=Shrinkage percentage ratio	**P.I.= Plasticity Index**
Ø Init.= Initial moisture content	

Shrinkage is fast for coarse grained material on the other hand the initial shrinkage is dominated by the fraction small particles and the final shrinkage by coarse fraction. The initial shrinkage is faster and the final shrinkage is slower. Based on the obtained values for shrinkage percentage ratio (Table 3) it can be concluded that the soils in study areas exhibit high potential of swell and shrinkage as a result of existing large amount of expandable minerals (smectite minerals group) in vertisols and high amount of clay fraction (Table 2).

The stepwise multiple linear regression relationship established between width of crack and (Total carbonate, Sand fraction, Iron oxides and Electrical conductivity) properties. There is a strong relationship and highly significant correlation between width of cracks and previous soil properties (Sig.= 0.000003) (Fig.3). The percentage of the total carbonates Sand fraction, Iron oxides and Electrical conductivity on the width of cracks explained (74%) of variations in crack width. According to this discussion can be predicted width of cracks in vertisols under study depending on the below regression equation with high representation efficiency:

Predict. Width of crack =11.087- 0.985 Fe_2O_3-11.988EC+0.2969Sand+0.03101Total $CaCO_3$

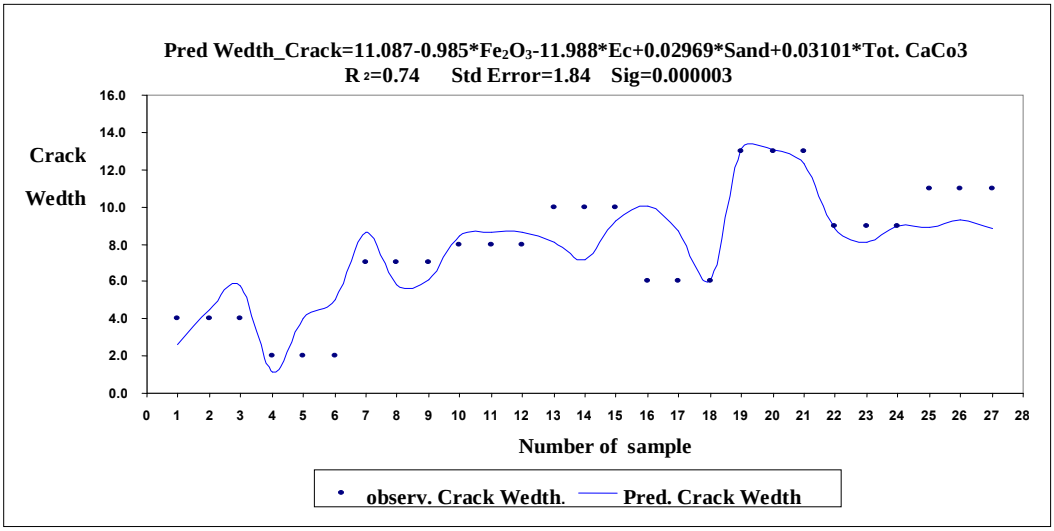

Fig. (3): Effect of (Iron oxides, EC, Sand, and total CaCO3) in width of crack with using stepwise multiple linear regression equation.

On the other hand, the statistical analysis results indicated to the total and active carbonate effecting on the depth of cracks with high efficiency (R^2 = 0.83) and this relationship was very high significant (Sig.= 0.0001), therefore can be concluded the total and active carbonates consider as the major factors that are definite the depth of cracks in vertisols because both of them act to decrease depth of cracks, since the carbonates consider as cementing agents (Fig.4). According to this correlation relation can be predicted the depth of crack with using weighted estimation regression equation as a linear function of total and active carbonates:

Predict. Depth of Crack =10.692869+0.348307Active $CaCO_3$+0.060628Total $CaCO_3$

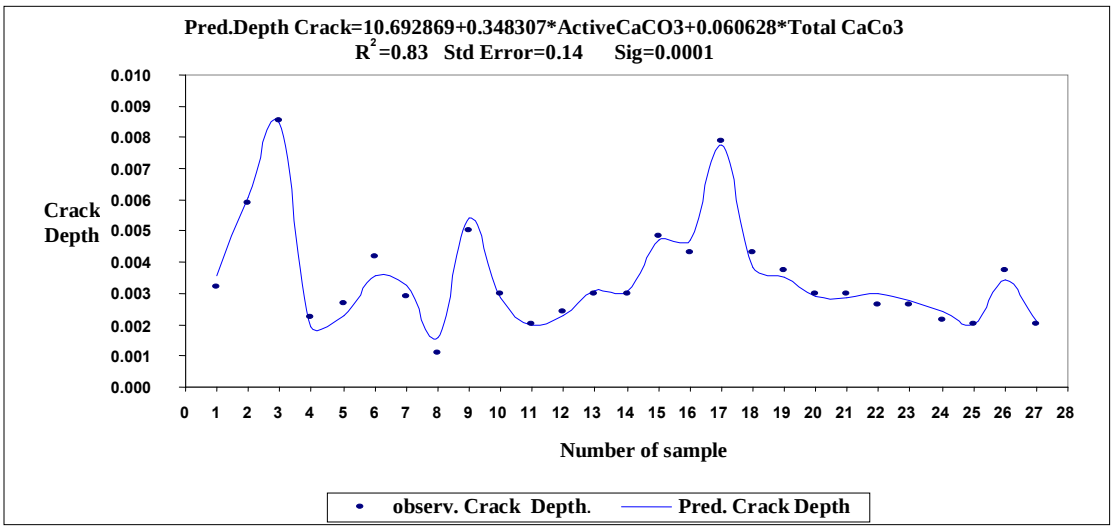

Fig. (4): Effect of (Total CaCO3 and Active CaCO3) in depth of crack with using weighted estimation regression equation.

In Fig. (5), can be observed the relationship between swelling percentage and (Clay activity, active carbonate, organic matter, sand fraction and electrical conductivity) properties is highly significant (Sig.= 0.00013), the results indicated to strong correlation between observed and predicted swelling percentage (R^2 = 0.67) depending on the stepwise multiple linear regression equation and the statistical analysis show great conformity between observed and predicted swelling percentage in vertisols of study areas:

Swelling-percent = 42.228-0.572 Active $CaCO_3$-0.0545Sand+41.809EC+50.9clay activity-0.913O.M.

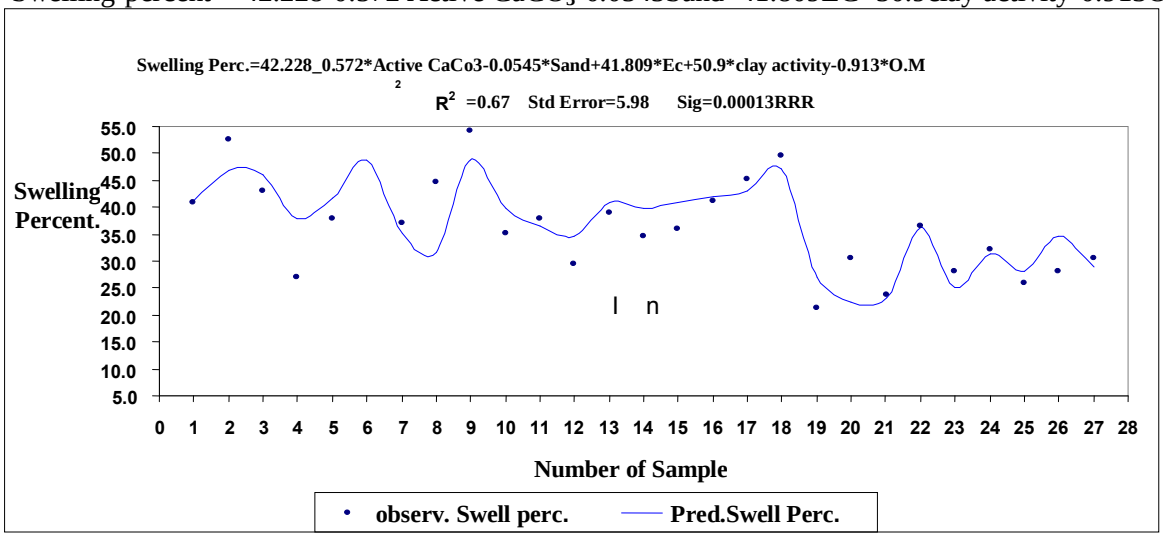

Fig. (5): The effect of (Active CaCO3, Sand, EC, Clay Activity, and Organic matter) in Swelling Percentage with using Stepwise Multiple linear Regression Equation.

Plasticity index is very high significant correlation with clay percentage and clay activity (Sig. = 0.00000001), and can be predicted it by using the following regression equation: Plasticity Index =15.362+46.445clay activity+0.0379 Total Clay

The best fit of plasticity index with total and clay activity is a linear multiple relationship (R^2 = 0.978), therefore the great conformity is found between observed and predicted plasticity index (97.8%) in vertisols of study locations (Fig.6).

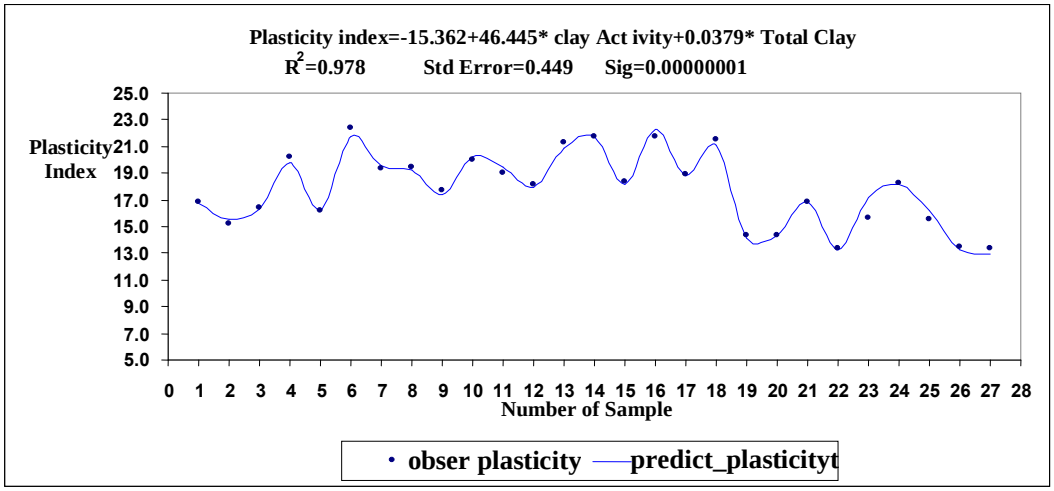

Fig. (6): Effect of Clay activity and Total Clay in Plasticity Index with using Stepwise Multiple Linear regression.

Based on clay activity values the study soils were classified as inactive clays (A.C.< 0.70).depending on the values of linear shrinkage percentages can be concluded the soils under study commonly exhibit high potential to swell and shrink (Table, 3). On the other hand the high liquid limit values of soils due to existing high amount of expandable minerals (Smectite minerals group) in vertisols and soil texture. The results explained the active clay in pedons of study areas is concentrated in surface layers for the soil and it is decreasing towards subsurface layers of pedons, with exception pedon (8) in sendi plain (Table, 3), therefore can be concluded the values of plasticity index are depending on the clay activity rather than total clay.

The values of porosity are small in pedon (3) of doban plain as compared with other soil pedons and this may be attributed to the soil compaction as a result of machinery using (Table, 2). There is a complex change of porosity in shrink-swell soils with moisture content variations and heterogeneity in the coarse fraction distribution. Consistency index values decreasing with depth in all pedons except pedon (9) and this may be due to concentrated organic matter in the surface layer of the soil and decreasing with depth, because of it is consider as cementing agent (Table, 1and 3).

CONCLUSIONS

1. The soils generally exhibit high potential to swell and shrinkage.
2. Highly significant correlation relationship of cracks (width and depth) with total and active carbonate, sand fraction, Iron oxides and EC.
3. Plasticity index depends on the active clay rather than total clay.
4. The total and active carbonates are considered as the major factors that define the depth of cracks in the soils of study areas.
5. Consistency index decreases with an increase in depth in all soil pedons.

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هفبه ندی لنافبه را سالوخه تێن جیوته کنیکی وکه لێشتێن ئاخێن چێرتیسول ل صارێزفه ها دهوکێ

کورتی

ئاخێن چیرتیسول ل صاریزفه ها دهوکێ رووبه ره کێ به رفرهه چه دفرن وهه یا نهو هیپ چه کولینه کا سه رانسه ری ل سه ر سالوخه تێن جیو ته کنیکی نه هاتی یه کرن کو صه یوه ندی یه کا موکم دفه ل که لێشتێن ئاخی یا هه ی ژبه ر چێ یه کێ صیدچی یه چه کولین لسه چێ صیوه ندێ بهێته کرن لسه ر بنه رتێ شیکرنا ستاتستیکی بو دانا هزرە کا روّن وئاشکرا لسهر چان سالوخه تان کو فه له ك دفرنفن دواری پاندن وئه ندازیاری دا بو بجهه ئینانا چێ ئرمانجێ ئف چه کولینه هاته کرن. (27) سامصلیّن ئاخیّ یێن سه ر ئه رد و بن ئه رد هاتنه وه رفرتن ژده شتیێن (دوبان و سلێچانی وسندی). وئه ف سامصله دێر کلس بوون. سالوخه تیێن ئاخی یێن فیزیائی و کیمیائی و جیوته کنیکی هاتنه ده ست نیشانکرن ب رێکێن صیچهری وبه ریناس. ئه نجامان وه ها خویاکر کو که لێشتێن لینیه ر ل ئاخێن چیرتیسول یێن ده شتا سلێچانه یا فره هزن ژ که لێشتێن لینیه ر ل هه ردوو ده شتێن دوبان و سندی وکێمترین بهایێ که لێشتا ل ده فه را سندیا ده رکه ت. ب ڤشتی هه چبه ندیه کا به روچاژی لنافبه را که لێشتێن لینیه ر وکاربوناتا(هه می وئه کتج) ل ئاخێن چێرتیسول ل ده فه رێ هاته دیتن.هه چبه ندیا لینیه را زه لیانێ لنافبه را فره یا که لێشتیّ وسالوخه تێن (کاربونات، صشکا خیزی، ئه کاسیدێن ئاسنی وڤه هاندنا کارە بێ) ووسان دیارکر هه چبه ندیه کا موکم وباش یا هه یی لنافبه را فره هیا که لێشتێن و سالوخه تێن مه ڤوتێن($sig=0.000003$). ئه نجامێن شی کرنا ستاتیکی ووسان دیارکر کو کارتێکرنا کاربوناتێن هه می و ئه کتج لسه ر کووراتیا که لێشتیّ وب پوستی یا بلند یا هه ی ($r^2=0.83$) وئه چ هه چبه ندیه ڤه له ك یا بلند وب ریژا ($sig=0.0001$). ئه نجامان ووسان دیارکر کو وه ك هه چیه ك مه زن لناچبه را وه رمێنا راست و ریژا صه یامکری (صێش بین کری) ل ئاخێن چێرتیسول یا هه یی. باشترێن لێکپون بو ئیندیکسیّ صلاستیکیدڤه ل ریژا Clay یا هه می و ئه کتج یا ب رێ یا هه چکێش صرئالی ویا صه یسك دوو (Second degree polynomial) هاته دیتن ($r^2=0.978$). ل سه ر بنه رتێ به هایی پالاکیا Clay ئاخێن چه کولیّن لسه ر هاته کرن هاتنه چاچارتنکو دبنه ئاخێن نه ئه کتج یان نه پالاك (پالاکیا Clayکێمتری 0.70) سالوخه تێن جیوته کنیکی ئاماژه بهندێ دکه ن بو کێمیا ئیندکسیّ consistency دڤه ل ڤورانیێ لسه ر هه می نه مونێت ئاخێن ژبلی صیدون ژمارە (9) و ئه چه ژی چه دڤه ریت صتریا ماددێ ئورڤانیك ل ته خێن سه ر ئاخیّ و کێمیا وان کووراتی یی. دهێته به ر ده ست کرن کو ئاخێن چه کولین لسه ر هاتی یه کرن توانایکا باش یا وه رمێن و که لێشتان یا هه ی و هه چبه سته کا بلند بو ریژا وه مینێ دڤه ل پالاکیا کلیێ و کاربونات یێت پالاك وماددێ ئورڤانێك و خیزی و هه چبه سته کا رە بای یا هه ی.

العلاقة بين الصفات الجيوتكنيكية والشقوق لترب الفيرتيسول في محافظة دهوك

الخلاصة

ترب الفيرتيسول تغطي مساحات واسعة في محافظة دهوك ولا توجد دراسة شاملة للصفات الجيوتكنيكية فيها والتي لها علاقة وثيقة بالتشققات في ترب الفيرتيسول لذلك من المهم دراسة هذه العلاقة اعتمادا على التحليل الأحصائي من أجل أعطاء فكرة واضحة حول هذه الصفات والتي تعتبر مهمة جدا في حقلي الزراعة والهندسة ولأجل تحقيق هذا الهدف تم تنفيذ هذه الدراسة. (27) عينة تربة سطحية وتحت سطحية تم جمعها والتي تمثل ترب الفيرتيسول في محافظة دهوك (سهل دوبان وسهل السليفاني وسهل السندي). ترب الدراسة كانت ذات محتوى عالي من الكلس.صفات التربة الفيزيائية والكيميائية والجيوتكنيكية تم تقديرها اعتمادا على الطرق القياسية المعتمدة. أوضحت النتائج أن التشقق الخطي في ترب الفيرتيسول لسهل السليفاني كانت أكبر من قيم التشقق الخطي في سهل دوبان وسهل السندي وكانت أقل القيم في ترب الفيرتيسول لمنطقة سهل السندي. عموما وجدت علاقة عكسية بين قيم التشقق الخطي والكاربونات (الكلية والفعالة) في ترب الفيرتيسول لمناطق الدراسة. أثبتت علاقة الأنحدار الخطي المتعدد بين عرض الشق وصفات (الكاربونات الكلية، مفصول الرمل، أكاسيد الحديد، والتوصيل الكهربائي) وجود علاقة أرتباط قوية وعالية المعنوية بين عرض الشق والصفات المذكورة آنفا (sig=0.000003). أشارت نتائج التحليل الأحصائي الى تأثير الكاربونات الكلية والفعالة في عمق الشق وبكفاءة تمثيل عالية (r^2=0.83) وكانت هذه العلاقة ذات معنوية عالية جدا(sig=0.0001). أوضحت النتائج تطابقا كبيرا بين نسب الأنتفاخ الحقيقية والنسب التي تم التنبؤ بها في ترب الفيرتيسول لمناطق الدراسة. أن أفضل تطابق لدليل اللدانة (المطاطية) مع الطين الكلي والفعال هومن خلال المعادلة متعددة الحدود ومن الدرجة الثانية (Linear multiple regression equation) وبدرجة معنوية عالية r^2 = (0.978). أعتمادا على قيم فعالية الطين فأن ترب الدراسة صنفت على أنها ذات أطيان غير فعالة (فعالية الطين أقل من 0.70). الصفات الجيوتكنيكية أشارت الى نقص في قيم دليل القوام مع العمق في جميع بيدونات الدراسة ما عدا البيدون (9) وهذا ربما يعزى الى كمية المادة العضوية في الطبقة السطحية للتربة ونقصها مع العمق. يمكن الأستنتاج بأن ترب الدراسة تظهر قدرة عالية للأنتفاخ والتشقق ويوجد قوة أرتباط معنوية عالية لنسبة الأنتفاخ مع فعالية الطين والكاربونات النشطة والمادة العضوية والرمل والتوصيل الكهربائي.

CHEMISTRY OF RAINFALL AND ITS COMPONENTS UNDER PINE FORESTS IN DOHUK GOVERNORATE

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ABSTRACT

The study was carried out at Zawita pine forests (*Pinus brutia* Ten.) during the water-year 2010-2011. The area is located about 17 km northeast of Duhok city in Kurdistan Region of Iraq. Two forest stands were selected, the area for each one was 900 m^2. One for the natural pine forest and the other for the artificial pine plantation. The results showed that the concentration of cations and anions increased after the rainfall passed through the canopy and flowed via the bole. The sequence of total cations and anions concentration decreased in the order of: stemflow > throughfall > gross rainfall. Cations concentration for gross rainfall in natural pine forest and artificial pine plantation decreased in the order of: Ca^{2+}> Mg^{2+}> Na^{+} > K^{+}, were 28.6, 8.89, 7.11 and 5.43 mg/L; 27.44, 8.27, 5.76 and 4.23 mg/L respectively. But this sequence changed in throughfall and stemflow in both stands to become Ca^{2+}> Mg^{2+}> K^{+} > Na^{+}, were 66.21, 25.32, 16.9 and 11.15 mg/L; 98.80, 36.45, 25.01 and 16.6 mg/L in natural pine forest, while in artificial pine plantation were 46.64, 19.82, 11.27 and 9.29 mg/L; 75.06, 25.20, 17.48 and 13.21 mg/L respectively. Anions in gross rainfall in both stands decreased in the order of: HCO_3^-> Cl^-, were 75.95 and 32.79 mg/L in natural pine forest while for artificial pine plantation were 72.40 and 31.73 mg/L respectively, and the sequence in throughfall and stemflow in both stands of natural pine forest and artificial pine plantation were 141.92 and 70.56, 127.45 and 63.05mg/L for throughfall and for stemflow were 197.07 and 83.84, 174.7 and 77.32 mg/L respectively. The results also indicated that the pH values slightly increased in throughfall and decreased in stemflow as compared with gross rainfall.

***KEYWORDS*:** Gross rainfall, throughfall and stemflow chemistry, throughfall and stemflow deposition, Zawita pine forests

1. INTRODUCTION

Precipitation falling over a forested watershed does not fall directly to the ground but rather is diverted by needles, leaves, branches, and stems (Steinbuck, 2002). It is partitioned into three components before reaching the forest floor and have a very significant effect on water balance and the nutrients cycle in forest ecosystem.

Three main sources of water-soluble ions in rainwater of the area were from sea salt aerosols (Na^+, Cl^- and Mg^{2+}), anthropogenic pollutants (H^+, NO_3^-), and mixing sources associated with sulfate (SO_4^{2-}, NH_4^+ and Ca^{2+}), (Lin *et al*., 1999). The chemical composition of throughfall and stemflow water differs from that of gross precipitation because of dry deposition of aerosols and gases in the canopy and canopy exchange (Meiresonne *et al.*, 2007). The throughfall chemistry was changed when passing through tree canopies (Zhang *et al.*, 2007). In such studies, analysis for the quality of rain water before reaching the forest cover and after entering the crown should be performed. The chemicals of precipitation that reaches the forest floor is influenced by chemical and hydrological characteristics of the incident precipitation, washoff of dry-deposited materials from canopy surfaces, washoff of material transported from within canopy tissues prior to the precipitation event, and absorption or release of substances by the plants and their associated micro flora during the precipitation event (Parker, 1983; Lovett *et al*., 1989). Dry and wet deposition of nutrients from the atmosphere is determined by regional environmental and climatic conditions. Precipitation chemistry varies greatly from region to another depending on the origin of the air masses and types of pollution in the region (Parker, 1983). The throughfall chemistry was notably changed strongly when passing through forest canopies (Zhang *et al*., 2007). The nutrient concentration of the throughfall depends on many different factors such as: volume of rainfall, location of the forest, tree stand composition and tree age (Neary and Gizyn, 1994). Stemflow chemistry depends on type of trees, bark texture and intensity of the storm (Levia and Frost, 2003; Crockford and Richardson, 2000). The objectives of this study were to find the influence of the *Pinus brutia* Ten. canopies and stems on plant nutrient depositions through throughfall and stemflow in both of the natural pine forest and

artificial pine plantation and to estimate the monthly and annual amounts of the some cations and anions reaching the floor of the natural pine forest and artificial pine plantation in (Kg/ha/year).

2. MATERIALS AND METHODS

2.1. SITE DESCRIPTION

The study was carried out at Zawita-Swaratoka watershed area. The area is located about 17 km northeast of Duhok city in Kurdistan Region of Iraq. The study area located within Zawita sub-watershed, which is a part of natural pine forest. The other part of the natural pine forest is at the Atrush district considered as the lower part of Zawita–Swaratoka watershed. The study started during the water–year 2010-2011 in Zawita Pine (*Pinus brutia* Ten.), which is composed of the natural pine forest about 830 hectares (Gulcur and Kettenah, 1972) and artificial pine plantation about 200 hectares (Reports of Zawita Forests and Horticulture Office, 2010). Two stands were selected fenced using Iron fences for the purpose of the present study. One of them for the natural pine forest which is located in the northern aspect of the mountain (latitude 36° 53′ N, longitude 43° 08' E) and elevation 960 m amsl.

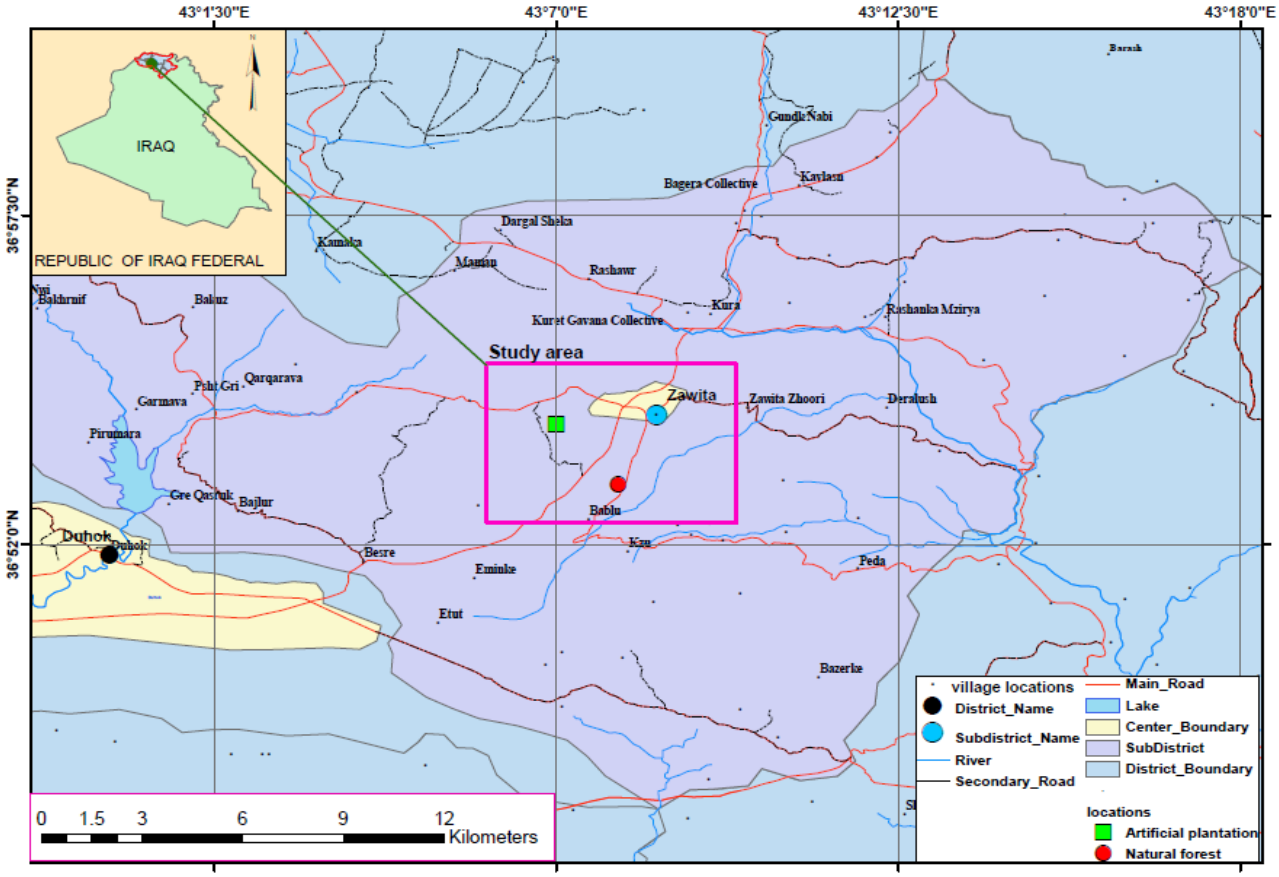

Fig. (1): Location map of the study area (Kurdistan map, 2010).

The total basal area was 19.63 m^2/ha, mean tree height and diameter at breast height (DBH) were 14 m and 40.5 cm, respectively, and the average age of the tree based on measured at breast height was 59 years (ranged between 32-109 year) and the other for the artificial pine plantation which is located in the southern aspect of the mountain (latitude 36° 54' N, longitude 43° 07' E) and elevation 971 m above mean sea level (Figure 1). Pine plantations planted in Zawita mountainous are distributed on contour lines. The distance between trees is about 3 m, while the distance between the rows is about 4 m. The total basal area was 12.2 m^2/ha., mean tree height, diameter and the average age of the trees at breast height (DBH) were 10 m, 19.58 cm and 28 years, respectively. Each of the stand area equal to 900 m^2. The terrain is mountainous which is mostly steep to very steep. Flat or gentle slopes are rare, in which most of them distributed as small patches in valley bottom, except in the northern part where the topography is gentle or flat. The soils of the Zawita-Swaratoka watershed consist of rough broken and stony land of the mountain region, belong to groups of lithosols, Rendzina and Brown soils (Buringh, 1960). The soil of Zawita belongs to reddish brown soils groups with loamy surface soil and sandy loam in sub-soil. Exposed red areas common in this watershed are marls of Gercus formation rock in Zawita where pine trees still grow. The calcium content of the soils in the watershed is extremely high. It was observed during the field study that the soils of the watershed are heavy textured, mostly clayey and clayey loam. Gulcur and Kettenah (1972) noted that the pH varies between 7.7 to 8.3, due to high calcium content. The area mainly belongs to the forest region, in which the Oak trees are predominant with *Quercus infectoria, Qercus aegilops* and *Quercus libani. Pinus brutia* is located around Zawita and adjacent hills in the north. *Juniperus oxycedrus, Pistacia khinjuk* and *Crataegus spp.* are also associated with these species. The climate of the study area is similar to the Mediterranean climate conditions. Mediterranean or Dry Summer Subtropical Climate Csa (Lands border the Mediterranean Sea) is a type locality for this climate (Köppen- Geiger climate classification). The climate is characterized by warm to hot, dry summer and mild to cool and rainy winter.

2.2. FIELD MEASURMENTS SAMPLES COLLECTION AND ANALYSIS

Gross rainfall for chemical analysis was sampled with four manual rain gauges, each consisted of a plastic funnel 17.9 cm diameter connected to 5 liter plastic container and one standard recorder rain gauges and located on an treeless spot adjacent to the two forest stands. Throughfall was sampled using eighteen manual rain gauges which were randomly distributed under tree canopies of each stand. Stemflow was collected from six selected pine trees using open rubber collars, spiraled around the stem of each tree at the level of the breast height (DBH) and connected to 20-

liter plastic container. Stemflow was sampled randomly at six locations for each stand. Measured volumes were converted to mm depth following each storm. Gross rainfall, throughfall and stemflow volumes were measured and samples have been prepared for chemical analysis of each storm Tables (1 and 2). Due to insufficient throughfall collected in each instrument for chemical analysis especially in the low rainstorm, the throughfall for every six samples near from each other were mixed together to form a composite sample as one sample. For the previous reasons, the stemflow for every two samples also were collected together as one sample.

Table (1): Total monthly of the gross rainfall, throughfall and stemflow (mm) in natural pine forest.

Months	Gross rainfall(P_g)	Throughfall (T_h)	Stem flow (S_f)
December	107.60	84.58	0.21
January	156.08	109.75	0.46
February	115.11	75.60	0.31
March	43.30	25.33	0.08
April	197.44	133.07	0.49
May	32.57	24.04	0.04
Sum	652.1	452.37	1.59

Table (2): Total monthly of the gross rainfall, throughfall and stemflow (mm) in artificial pine plantation.

Months	Gross rainfall(P_g)	Throughfall (T_h)	Stem flow (S_f)
December	96.11	83.76	0.75
January	139.43	103.01	0.78
February	88.40	64.77	0.40
March	41.92	29.34	0.18
April	174.04	133.59	0.78
May	35.05	29.19	0.12
sum	574.95	443.66	3.01

Electrical conductivity and pH values were measured for all samples immediately in the field by using EC-meter model HI 9635, conductivity/ TDS meter, HANNA and adjusted to 25°C as used by (Hesse, 1972) and pH meter model HI8417–HI8519 Microprocessor, HANNA. After EC and pH measurements in the field, the water samples were transferred to laboratory and filtered through Whatman No. 42 filter paper. All samples were stored and maintained at 4°C for analysis. Sodium and potassium (Na^+, K^+) were measured by flame-photometric method using flame photometer Model, JENWAY, LDT., FELSTED, DUNMOW, ESSEX, CM63LB, MODE: FFP 7., while Calcium and magnesium (Ca^{2+}, Mg^{2+}) were measured by titration with versenate (EDTA, 2Na). Bicarbonate (HCO_3^-) also was measured by titration with HCl 0.01N. Chloride (Cl^-) was measured by titration with silver nitrate ($AgNO_3$) and $K_2Cr_2O_4$ as indicator (Page *et al.*, 1982). The monthly and annual amount of cations and anions were calculated for each stand in which gross rainfall, throughfall and stemflow in (Kg/ha). Deposition fluxes were estimated on the basis of the differences between the fluxes in throughfall and gross rainfall in Kg/ha. Deposition ratio was calculated also; a ratio between the throughfall deposition and gross rainfall (Liu, 2003).

3. RESULTS AND DISCUSSION

3.1. Concentration Of Elements In The Gross Rainfall, Throughfall And Stemflow

Table (3) shows that the average cations concentration (mg/L) of gross rainfall in natural pine forest and artificial pine plantation took the following sequence Ca^{2+}> Mg^{2+}> Na^+> K^+. Similar trend has been documented for pine forest (*Pinus brutia* Ten.) (Salim, 2008). These sequences changed after passing gross rainfall through tree canopy for throughfall in natural pine forest and artificial pine plantation to Ca^{2+} > Mg^{2+}> K^+> Na^+. The change of potassium sequences in both pine forests is due to the easy washing of potassium, because it is not so tightly bound in structural tissues or enzyme complex (Staelens *et al*., 2003). This agrees with (Feng *et al*. 2001) in studying pine tree in northern china. The ratio between the concentrations of throughfall to the concentration of gross rainfall in natural pine forest and artificial pine plantation of the cations Ca^{2+}, Mg^{2+}, Na^+ and K^+ were (2.32, 2.85, 1.57 and 3.11) and (1.7, 2.4, 1.61 and 2.66), respectively. These ratio remained in stemflow in the both of the natural pine forest and artificial pine plantation as in throughfall which agrees with (Salim, 2008). It was noticed that the ratio between the concentrations in stemflow to the concentration of gross rainfall in the natural pine forest and artificial pine plantation of the cations Ca^{2+}, Mg^{2+}, Na^+ and K^+ were (3.45, 4.100, 2.33 and 4.61) and (2.74, 3.05, 2.29 and 4.13), respectively. Table (3) also shows that the average anion concentration (mg/L) of gross rainfall, throughfall and stemflow in the natural pine forest and artificial pine plantation decreased in the same order as HCO_3^- > Cl^- . This is consistent with (Jabbori and Ibrahim, 1989) for the study of *Pinus pinea* in Ninevah plantation in northern Iraq. The ratio between the concentration of throughfall to the concentration of gross rainfall in the natural pine forest and artificial pine plantation of the anion HCO_3^- and Cl^- were (1.87 and 2.15) and (1.76 and 1.99), respectively. While the ratio between the concentration of stemflow to the concentration of gross rainfall in the natural pine forest and artificial pine plantation were (2.59 and 2.56) and (2.41and 2.44), respectively.

Additionally, it was noted from the Table (3) that the values of pH in the natural pine forest and artificial pine plantation in gross rainfall ranged between (6.52-7.85) and (6.59-7.91), respectively. It is similar to the values obtained by (Salim, 2008) for the study of the quantity and quality of precipitation reaching *Pinus brutia* Ten. and *Pistacia khinjuk* Stock. stands in the Aqra area which ranged between (6.55-7.80). Also, it was noticed that pH values increased after passing rainfall through tree canopy due to increasing the concentrations of bicarbonate, calcium and magnesium which is found by (Takagi, *et al*. 1997). The decrease in pH values was observed after passing rainfall through trees stems in both natural and artificial, this is due to the characteristic of the bark of the coniferous (Marchetti, *et al*. 2002). In general, the concentration of cations and anions of throughfall for the natural pine forest was greater than for the artificial pine plantation because of forest density and the canopy cover was larger than that for

the artificial pine plantation. Similarly the concentration of cations and anions of stemflow in the natural pine forest was larger than that for the artificial pine plantation because of the height and diameter of the natural pine trees larger compared with artificial pine plantation trees providing a longer period of time and more surface area for water flow to the stem.

Table (3): Average annual concentration of cations, anions, values of pH and EC of the gross rainfall, throughfall and stemflow in the natural pine forest and artificial pine plantation (mg/L).

Sites		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	pH	EC (dS/m)
Natural pine forest	Gross rainfall (P_g)	28.6	8.89	7.11	5.43	75.95	32.79	6.52-7.85	2.07
	Throughfall (T_h)	66.21	25.32	11.15	16.9	141.92	70.56	6.73-7.99	2.45
	(T_h) / (P_g)	2.32	2.85	1.57	3.11	1.87	2.15		1.18
	Stemflow (S_f)	98.80	36.45	16.6	25.01	197.07	83.84	5.98-7.48	2.66
	(S_f) / (P_g)	3.45	4.10	2.33	4.61	2.59	2.56		1.29
Artificial pine plantation	Gross rainfall (P_g)	27.44	8.27	5.76	4.23	72.40	31.73	6.59-7.91	2.03
	Throughfall (T_h)	46.64	19.82	9.29	11.27	127.45	63.05	6.66-7.97	2.34
	(T_h) / (P_g)	1.7	2.4	1.61	2.66	1.76	1.99		1.15
	Stemflow (S_f)	75.06	25.20	13.21	17.48	174.7	77.32	6.01-7.55	2.58
	(S_f) / (P_g)	2.74	3.05	2.29	4.13	2.41	2.44		1.27

In general, there was fluctuation in the values of cations, anions, pH and electrical conductivity during successive rain showers throughout the study period. This depended on the density of rain showers, wind speed, dry periods between the rain showers and the amount of interception loss (Figures 2-17).

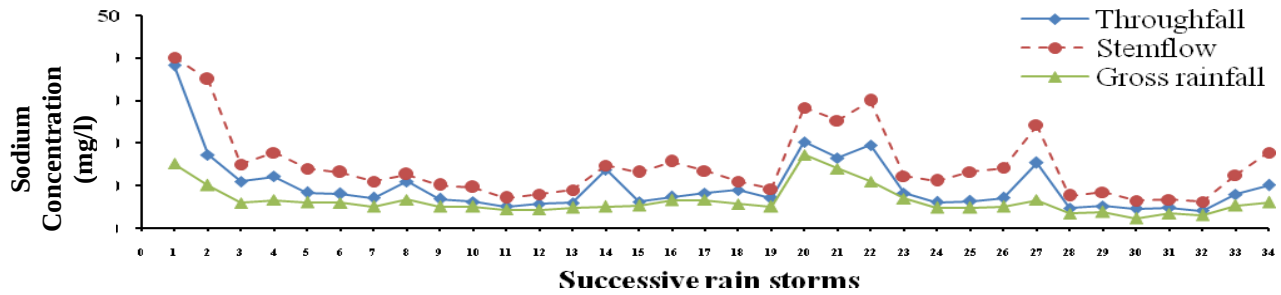

Fig. (2): Sodium concentration during successive rain storms in natural pine forest.

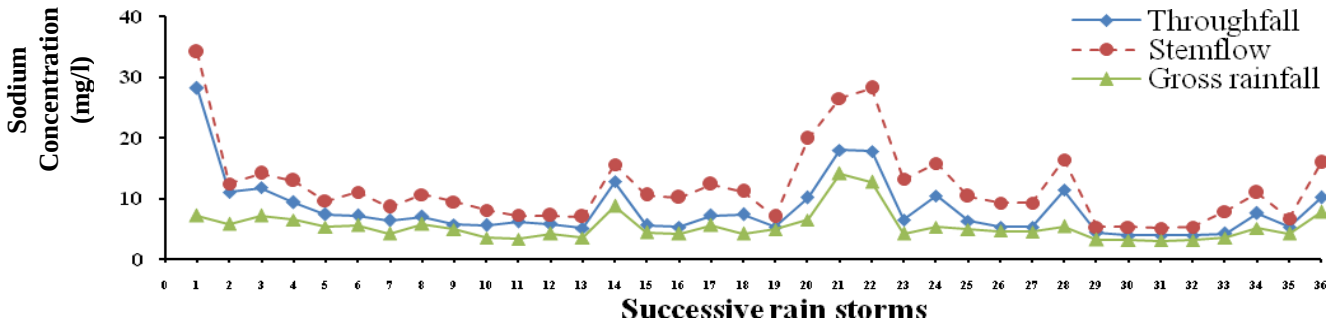

Fig. (3): Sodium concentration during successive rain storms in artificial pine plantation.

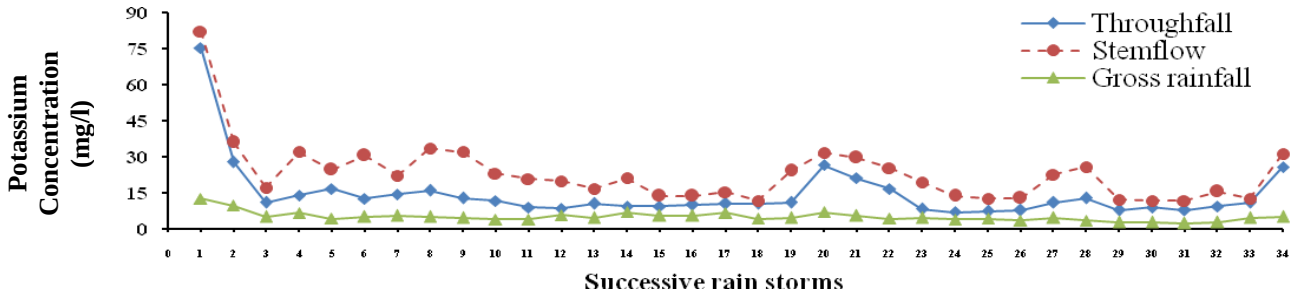

Fig. (4): Potassium concentration during successive rain storms in natural pine forest.

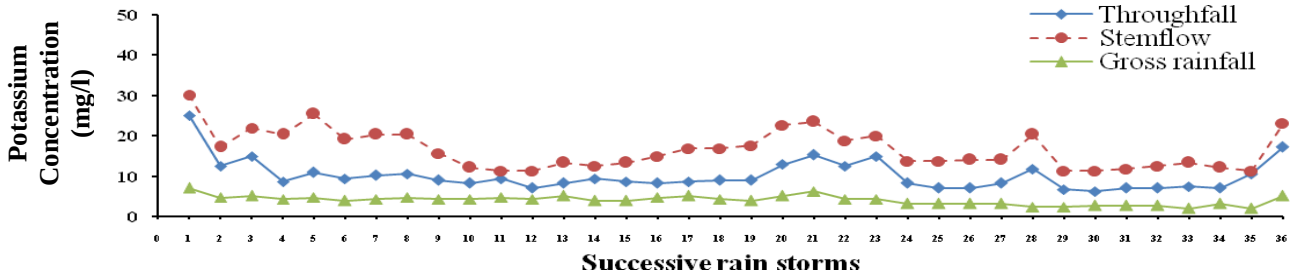

Fig. (5): Potassium concentration during successive rain storms in artificial pine plantation.

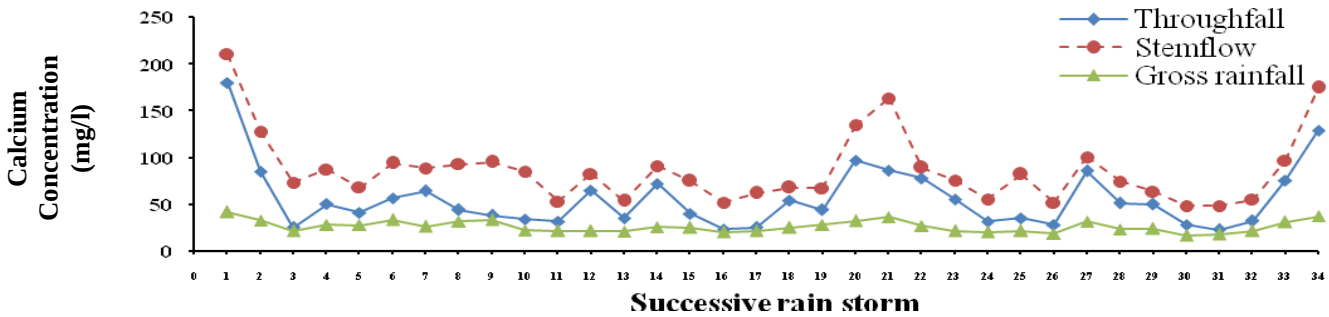

Fig. (6): Calcium concentration during successive rain storms in natural pine forest

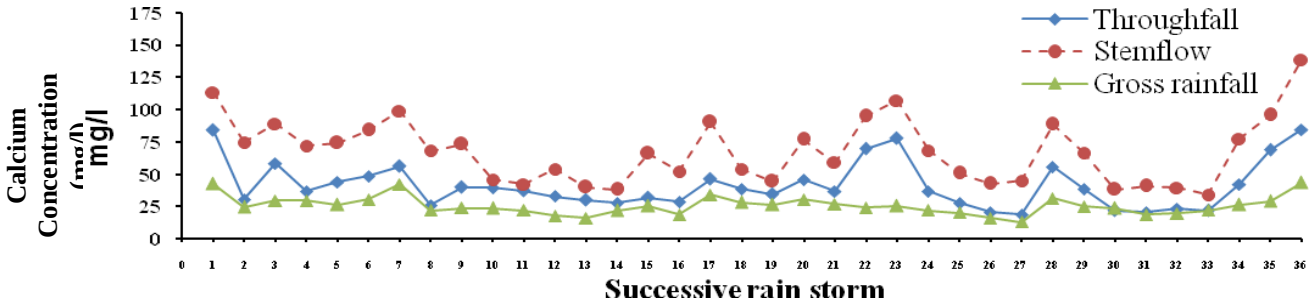

Fig. (7): Calcium concentration during successive rain storms in artificial pine plantation.

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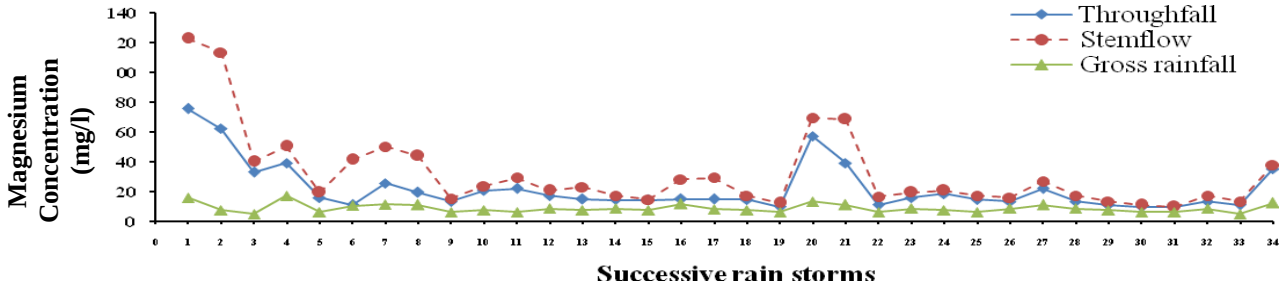

Fig. (8): Magnesium concentration during successive rain storms in natural pine forest

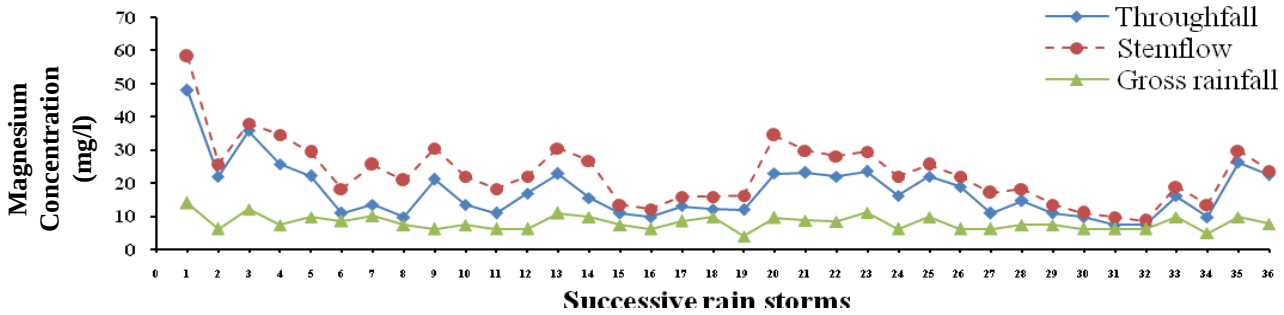

Fig. (9): Magnesium concentration during successive rain storms in artificial pine forest.

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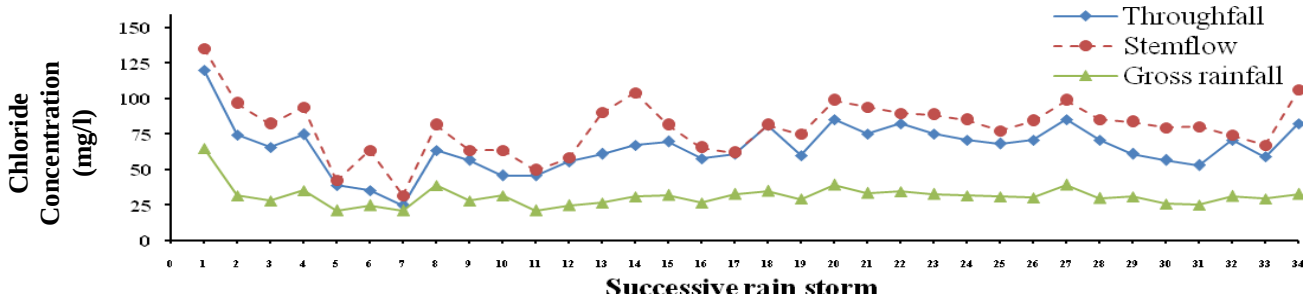

Fig. (10): Chloride concentration during successive rain storms in natural pine forest.

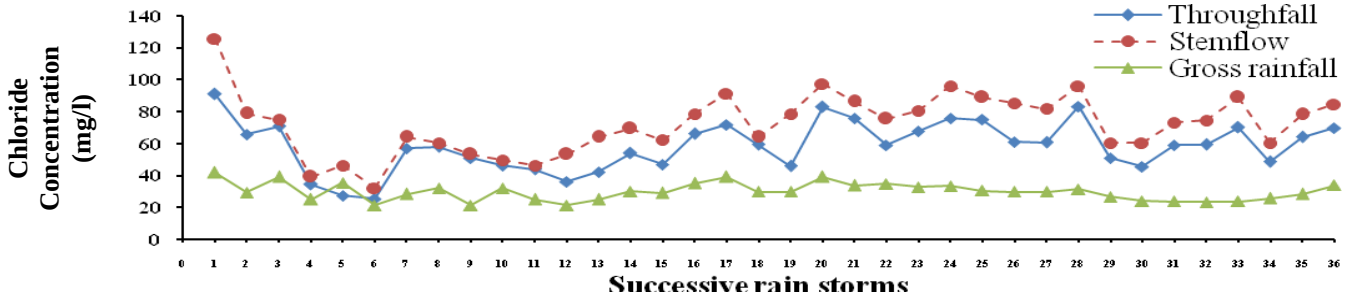

Fig. (11): Chloride concentration during successive rain storms in artificial pine plantation.

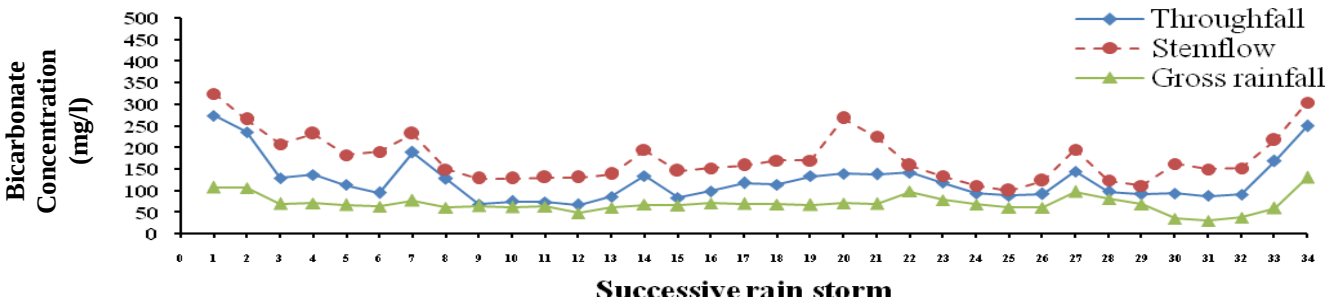

Fig. (12): Bicarbonate concentration during successive rain storms in natural pine forest.

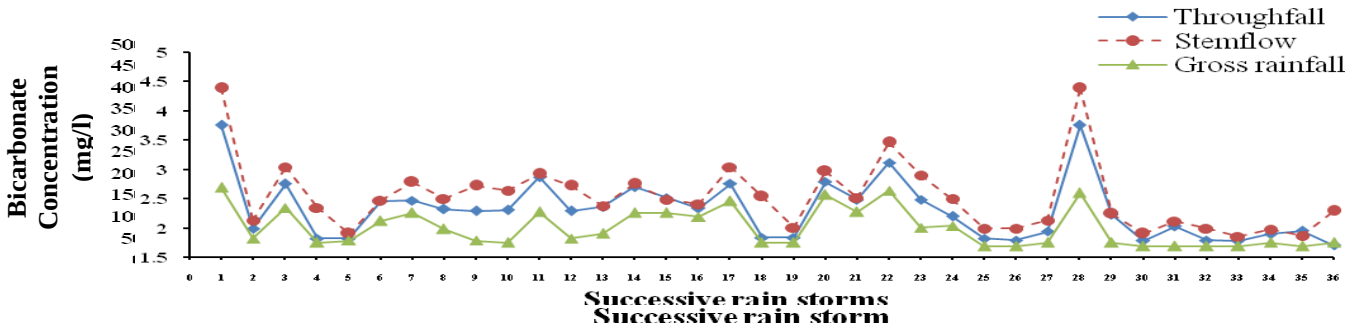

Fig. (13): Bicarbonate concentration during successive rain storms in artificial pine plantation.

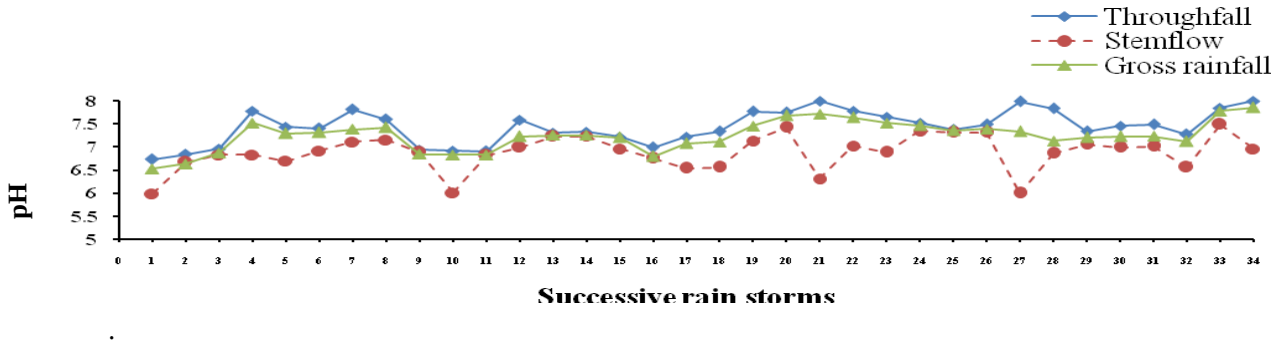

Fig. (14): pH value during successive rain storms in natural pine forests.

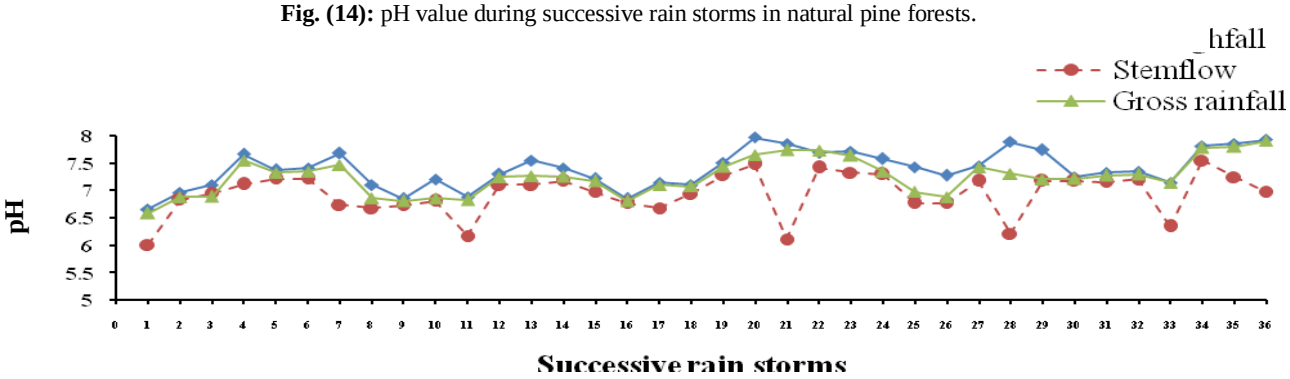

Fig. (15): pH value during successive rain storms in artificial pine plantation.

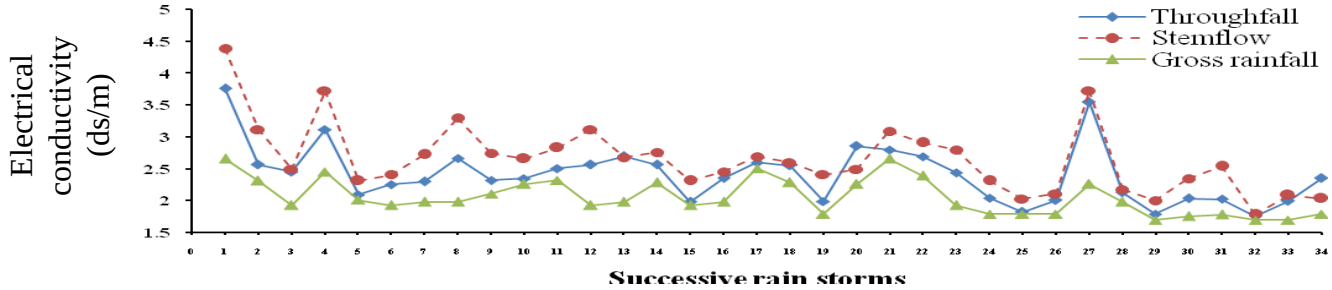

Fig. (16): Electrical conductivity during successive rain storms in natural pine forest.

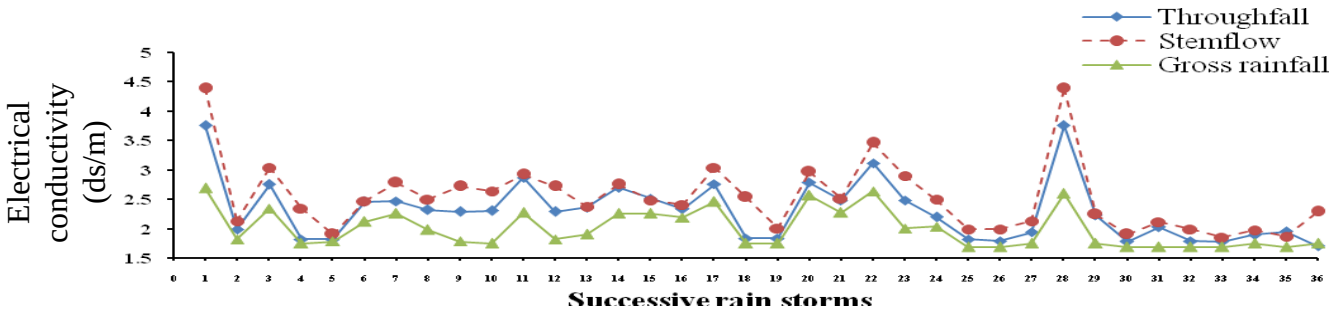

Fig. (17): Electrical conductivity during successive rain storms in artificial pine plantation.

3.2. Deposition Of Elements By Throughfall And Stemflow

In forest ecosystem the chemical compositions of rainwater are strongly altered by processes within the tree canopies before reaches the forest floor as throughfall, stemflow and enters the soil (Herrmann, *et al*. 2006). Throughfall and stemflow are two major pathways for forest nutrient cycling and they are necessary to establish both water and nutrient (Thimonier, 1998). Table (4) show total deposition, deposition fluxes (Kg/ha/yr) and annual deposition ratio in the natural pine forest and artificial pine plantation.

Table (4): Total deposition, deposition fluxes and annual deposition ratio in the natural pine forest and artificial pine plantation.

Ionic	Total deposition (Kg/ha/yr)				Deposition fluxes (Kg/ha/yr)		Deposition ratio	
	Natural pine forest		Artificial pine plantation		Natural pine forest	Artificial pine plantation	Natural pine forest	Artificial pine plantation
	Gross rainfall	Throughfall	Gross rainfall	Throughfall				
Ca^{2+}	129.82	202.44	116.8	174.77	72.62	57.97	1.56	1.5
Mg^{2+}	50.51	98.54	46.15	82.5	48.03	36.35	1.95	1.79
Na^{+}	30.61	39.27	28.19	34.14	8.66	5.95	1.28	1.21
K^{+}	25.84	57.67	21.54	45.18	31.83	23.64	2.23	2.1
HCO_3^{-}	385.5	511.79	372.2	452.82	126.29	110.62	1.33	1.3
Cl^{-}	189	282.59	167.61	247.62	93.59	80.01	1.5	1.48

Annual depositions of cations Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} that reached for the around surface through gross rainfall under the natural pine forest and artificial pine plantation were 129.82, 50.51, 30.61 and 25.84 kg/ha/yr; 116.8, 46.15, 28.19 and 21.54 Kg/ha/yr respectively. The sequences of cations are: $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$. The annual deposition of such cations increased after passing tree canopy in natural pine forest to 202.44, 98.54, 39.27 and 57.67 Kg/ha/yr respectively, while in artificial pine plantation the annual deposition increased to 174.77, 82.5, 34.14 and 45.18 kg/ha/yr, respectively and the sequence were changed to become : $Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$. Deposition fluxes for cations Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}, and in natural pine forest were 72.62, 48.03, 8.66 and 31.83kg/ha/yr, while their deposition ratios were 1.56, 1.95, 1.28 and 2.23 respectively, while in artificial pine plantation were 57.97, 36.35, 5.95 and 23.64 kg/ha/yr, and deposition ratios were 1.5, 1.79, 1.21 and 2.1 respectively. The deposition of calcium is higher than other cations in natural pine forest and artificial pine plantation, due to that in the arid and semi arid regions the calcium carbonate is the main source of calcium in the rainfall. The highest deposition ratio for potassium is in natural pine forest and artificial pine plantation because it is not so tightly bound in structural tissues or enzyme complexes (Staelens, *et al*., 2003). The annual depositions of anions HCO_3^{-} and Cl^{-} and in gross rainfall for the natural pine forest were 385.5 and 189.0 kg/ha/yr, while for artificial pine plantation were 372.2 and 167.61Kg/ha/yr respectively. These depositions were changed after passing through tree canopy to 511.79 and 282.59 Kg/ha/yr 482.82 and 247.62 Kg/ha/yr respectively. The sequences in gross rainfall, throughfall and stemflow were: $HCO_3^{-} > Cl^{-}$ Deposition fluxes for HCO_3^{-} and Cl^{-} were 126.29 and 93.59Kg/ha/yr, while the deposition ratios were 1.33 and 1.5 in natural pine forest. For artificial pine plantation they were 110.62 and 80.01Kg/ha/yr and for deposition ratio were 1.3 and1.48 respectively. In general deposition fluxes for all cations and anions in natural pine forest are higher than those artificial pine plantation because of the high forest density and canopy cover for natural pine forest than for artificial pine plantation. Tables (5 and 6) show monthly deposition for cations and anions in gross rainfall, throughfall and stemflow for the natural pine forest and artificial pine plantation.

Table (5): Amount of cations (Kg/ha/yr) reached by the natural pine forest and artificial pine plantation through gross rainfall, throughfall and stemflow.

Sites	Months	Gross rainfall				Throughfall				Stemflow			
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
Natural pine forest	December	31.25	15.17	7.93	6.69	59.71	40.02	12.42	17.03	0.37	0.17	0.04	0.12
	January	24.69	11.43	6.35	6.45	36.06	21.60	7.38	13.05	0.22	0.12	0.005	0.11
	February	25.81	9.00	5.91	3.91	22.45	10.65	6.53	7.37	0.14	0.05	0.02	0.04
	March	12.21	3.42	4.90	2.08	19.75	5.21	4.54	4.53	0.07	0.02	0.02	0.02
	April	31.06	10.12	4.55	5.88	52.24	18.33	7.31	14.6	0.36	0.09	0.04	0.07
	May	5.80	1.37	0.97	0.83	12.23	2.73	1.09	1.09	0.004	0.0007	0.0005	0.001
	Sum	129.82	50.51	30.61	25.84	202.44	98.54	39.27	57.67	1.10	0.44	0.13	0.36
Artificial pine plantation	December	30.99	12.15	6.28	5.30	50.85	30.38	11.30	15.47	0.78	0.37	0.20	0.2
	January	21.09	10.05	5.33	5.18	33.82	14.24	6.05	9.04	0.41	0.17	0.06	0.10
	February	19.18	7.99	5.05	3.83	19.99	10.30	5.43	5.59	0.18	0.10	0.05	0.05
	March	11.37	3.64	4.02	2.05	14.06	5.77	3.68	3.08	0.13	0.05	0.04	0.04
	April	28.9	10.12	6.00	4.31	45.63	17.05	6.56	9.39	0.49	0.11	0.05	0.09
	May	5.27	2.20	1.51	0.87	10.42	4.76	1.12	2.61	0.11	0.03	0.01	0.002
	Sum	116.8	46.15	28.19	21.54	174.77	82.50	34.14	45.18	2.10	0.83	0.41	0.50

Table (6): Amount of anions (Kg/ha/yr) arrived in the natural pine forest and artificial pine plantation through gross rainfall, throughfall and stemflow

Sites	Months	Gross rainfall		Throughfall		Stemflow	
		HCO_3^-	Cl^-	HCO_3^-	Cl^-	HCO_3^-	Cl^-
Natural pine forest	December	74.3	35.83	131.45	61.56	0.52	0.20
	January	82.20	44.3	92.52	53.05	0.61	0.29
	February	64.62	32.25	77.78	46.79	0.35	0.22
	March	34.17	14.13	34.72	19.85	0.13	0.07
	April	114.72	57.2	150.25	92.85	0.62	0.42
	May	15.49	5.29	25.07	8.49	0.01	0.003
Sum		385.5	189.0	511.79	282.59	2.24	1.20
Artificial pine plantation	December	71.03	33.60	126.69	63.59	0.45	0.51
	January	77.76	38.88	87.46	47.45	0.99	0.40
	February	57.85	26.04	60.61	34.08	0.52	0.27
	March	30.69	14.84	36.81	14.14	0.3	0.15
	April	110.5	46.02	139.67	77.6	1.00	0.82
	May	24.37	8.23	31.58	10.76	0.24	0.08
Sum		372.2	167.61	482.82	247.62	3.5	2.23

The highest deposition of sodium, potassium, calcium and magnesium for gathered gross rainfall, throughfall and stemflow samples, was in December because it included the first rain showers after a period of drought, while the lower deposition was in May due to lack of rainfall. The highest deposition of chloride and bicarbonate occurred in April because of the high quantity of rainfall and dust, while the lower deposition was in May month. In general the lowest deposition of all cations and anions was in May under natural pine forest and artificial pine plantation.

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کیمیایـا بارانێ و پێکهاتییێت وێ ل بن داربن دارستانا گـــاژا ل پاریزگەها دهوکێ
پشکا دارستان/ فاکولتیا چاندن و دارستان/ زانکویا دهوك/ هەرێما کوردستانێ.ئیراق

پوختــه

ئەڤ ڤەکولینه لسالا 2010-2011 هاتەکرن لناف دارستانا کاژێن زاویته، دەڤەر ب دووریا 17 کم دکەڤیته باکورێ روژهەلاتا دهوك ل هەرێما کوردستانا عیراقێ، دوو پارچه زەڤی روبەرێ هەرئێك ژوان دگەهشته 900 م۲ هاتنه هەلبژارتن، ئێك دارستانەکا خورسکی بوو و یادووێ پارچەکا دەستکرد بوو. د ئەنجامادا تیراتیا هەمی کاتایون و ئەنایونا زێدەبوو بشتی ناڤداچوونا بارانێ لسەر کولوخێ داریّ و بشتی ڤێداچوونێ و بڤی رەنگی: بارانێت ڤێداچوویی لسەر قورمی > بارانێت ناڤداچوویی > بارانێت دەڤەرێ . تێکرایێ تیراتیا کاتایونا ژ بارانێت دەڤەرێ بڤی رەنگی بوون : $K^+ < Na^+ < Mg^{2+} < Ca^{2+}$ و ب تیراتیا 28.6، 8.89، 7.11 و 5.43 ملگم/لـتر ل دارستانا سروشتی و 27.44، 8.27، 5.76 و 4.23 ملگم/لـتر ل یا دەستکر. دەدەمەکی دا بارانێت ناڤداچوویی و یێت ڤیچداچوویی ئەڤ زێنجیرە وەرگرت: $Na^+ < K^+ < Mg^{2+} < Ca^{2+}$ و ب تیراتیا 66.21، 25.32، 16.9 و 11.15 ملگم/لـتر بو بارانێت ناڤداچوویی و 98.8، 36.45، 25.01 و 16.6 ملگم/لـتر بو بارانێت ڤێداچوویی ل دارستانا سروشتی ل روی ئێك و 46.64، 19.82، 11.27 و 9.29 ملگم/لـتر بو بارانێت ناڤداچوویی و 75.06، 25.2، 17.48 و13.21 ملگم/لـتر بو بارانێت ڤێداچوویی ل یا دەستکر لـروی ئێك. هەروەسان چرپاتیا یان تیراتیا بارانا بو هەر دوو پارچا بڤی رەنگی بوون: $Cl^- < HCO_3^-$ وتیراتیا 75.95 و32.79 ملگم/لـتر ل دارستانا سروشتی، 72.40 و 31.73 ملگم/لـتر ل یا دەستکر لـروی ئێك . و ئەڤ زنجیرە بو بارانێت ناڤداچوویی و دڤێداچوویی بو هەردوو پارچا وەك خوّ ما بتیراتیا 141.92 و 70.56 ، 127.45 و 63.05 ملگم/لـتر بو بارانێت ناڤداچوویی 197.07 و 83.84 ، 174.7 و 77.33 ملگم/لـتر بو بارانێت ڤێداچوویی لـروی ئیك. هەروەسان زێدەبوونەکا سادە ل بهایێ (pH) هاتە دیتن بو ئاڤا بارانا د یا ناڤداچوویی بەرامبەر ڤێداچوویی و نزمیەك دیت ئەوا لسەر قورمی چوویی لێ بارانێت نە یێت ئەسیدی بوون، هەروەسان بهایێ (EC) زێدە بوو .

كيميائية الامطار و مكوناته تحت غابات الصنوبر في محافظة دهوك

الخلاصة

اجريت الدراسة خلال السنة المائية 2010-2011 في غابات صنوبر زاويتة الواقعة حوالي 17 كم شمال شرق مدينة دهوك، اقليم كوردستان العراق. تمت الدراسة من خلال اختيار قطعتين مساحة كل واحدة منهما 900 م^{2}، احداهما من غابة طبيعية و الثانية من مشجر اصطناعي. أظهرت النتائج زيادة تركيز جميع الكاتيونات و الأنيونات بعد نفاذ الأمطار من الغطاء التاجي و كذلك بعد جريانها على الساق حيث أخذ التسلسل الأتي: الأمطار الجارية على الساق > الأمطار النافذة > أمطار المنطقة المفتوحة. معدل تركيز الكاتيونات في أمطار المنطقة المفتوحة و للمشجرين أخذ التسلسل الأتي:

$K^{+} < Na^{+} < Mg^{2+} < Ca^{2+}$ و بتراكيز 28.6، 8.89، 7.11 و 5.43 ملغم/لترفي الغابة الطبيعية و 27.44، 8.27، 5.76 و 4.23 ملغم/لتر في المشجر الأصطناعي على التوالي. أما في الأمطار النافذة و الجارية على الساق فقد أخذ التسلسل الأتي: $Na^{+} < K^{+} < Mg^{2+} < Ca^{2+}$ و بتراكيز 66.21، 25.32، 16.9 و 11.15 ملغم/لترللامطار النافذة و 98.80، 36.45، 25.01 و 16.6 ملغم/لتر للامطار الجارية في قطعة الغابة الطبيعية و 46.64، 19.82، 11.27 و 9.29 ملغم/لتر للامطار النافذة و 75.06، 25.20، 17.48 و 13.21 ملغم/لترللامطار الجارية في قطعة المشجر الأصطناعي على التوالي. وأما معدل تركيز الأيونات السالبة في أمطار المنطقة المفتوحة و للمشجرين فقد أخذ التسلسل الأتي: $Cl^{-} < HCO_3^{-}$ و بتراكيز 75.95 و 32.79 ملغم/لترفي الغابة الطبيعية ، 72.40 و 31.73 ملغم/لتر في المشجر الأصطناعي على التوالي، ولم يتغير هذا التسلسل في الأمطار النافذة و الجارية على الساق لقطعتي الغابة الطبيعية و المشجر الأصطناعي و بتراكيز 141.92 و 70.56، 127.45 و 63.05 ملغم/لتر للامطار النافذة و 197.07 و 83.84، 174.7 و 77.32 ملغم/لتر للامطار الجارية و على التوالي. كما لوحظ ارتفاع بسيط في قيمته الـ (pH) لمياه الأمطار بعد نفاذها من التاج و حدوث انخفاض بسيط في قيمتها بعد جريانها على الساق الا أن الأمطار لم تكن حامضية. أما قيمة التوصيل الكهربائي فقد زادت بعد نفاذ الأمطار من التاج و جريانها على الساق و لكلتى المشجرين.

EFFECT OF DRYING FACTORS ON PROPERTIES OF *Eucalyptus camaldulensis* Den. BOARDS AT SUMMER SEASON

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ABSTRACT

The study has conducted on *Eucalyptus camaldulensis* Dehnh. to explore its suitability to sawn-board production. Ten of local eucalypt trees were converted into boards and subjected to drying throughout summer months. Three methods of drying, Two methods of sawing, and three board thickness were tested. Board quality was qualified by drying defects inspection on 180 boards for each defect. Results showed that the degree of collapse, cup and end split was mainly affected by sawing method, while board thickness was the main factor on bow. Drying methods was the only factor affected on twist, and together with board thickness affected both of moisture content and moisture gradient. Assessment of studied defects approved the validity of the tested species as sawn timber.

KEYWORDS: Drying factors, *E. camaldulensis*, Board properties, Summer season

INTRODUCTION

The demand on sawn wood according to (FAO, 2009) was 418,364,000 m³/year. The last ten years estimates referred that the expected wood demands in the next few years will be much higher than the current consumption. *Eucalyptus* species is one of the fastest wood producing trees. It has the ability to produce around 100 cubic meters per hectare annually. Some studies reported that there are about 18 Million hectare of Eucalypt in the world (Myburg *et al.*, 2006), and according to (Iglesias *et al.*, 2008) it was expected that in 2010 the total areas of *Eucalyptus* in the world will increase up to 20 Million hectare. Eucalypt is cultivated as an exotic tree worldwide. Range of distribution is extended from tropical to subtropical and warm temperate, and from arid to semi arid regions. It tolerates temperature from 3 to 5 C˚ in winter and in dry season it tolerates (34-45 °C) four to eight months or more and even more severe temperatures. Frosts are rare (5–20 days per year) according to (Mariani *et al.*, 1981).

In Iraq, Eucalypt has been introduced to the country as an exotic tree during the last century. Literature referred that more than twenty species of the genus were found in Iraq. The two main ones being *E.camaldulensis* and E. microtiheca, some other species as *E.largiflorens, E. sideroxylon,…etc.* were planted in an experimental attempts and till now could not be considered as established species (Rooitzsch and Reader,1969). It has been used for pulp, chipboard, fire wood, shelter belts… etc. In the middle and southern part of country, where a significant levels of high temperature are predominant in summer, the species could stand well and resist the sever drought conditions. Proper temperature and humidity rates as well as precipitation in Kurdistan offered better conditions for Eucalypt in summer. The situation is different in winter; it is not advisable to be planted at high elevations where long period of frost is expected during the season. The lack of industrializing wood products in Iraq, so in Kurdistan Region makes it difficult to have clear idea about the possibility of eucalypt utilization. Wide areas-

among big project of forestation were planted in Iraq since the mid of last century where *Eucalyptus* was the predominant species. Some of plantations were established in Kurdistan region. Unstable political and economical circumstances before 2003 led to sever deterioration of eucalypt plantations. Currently, serious efforts have been exerted for establishing a new forestation projects either by eucalypt or by other species.

It is well known that environmental conditions could have their effects on the wood properties and uses, also because of the scarcity of studies dealing with eucalypts wood in Iraq especially those related to its drying behavior, this study has planned to deal with the possibility of utilizing the species growing in Kurdistan for sawn board industry.

MATERIALS AND METHODS

The study was conducted in the Faculty of Agriculture and Forestry, University of Duhok, Sumeil, Duhok Governorate.

*A part of the second author's thesis.

Trees of *Eucalyptus camaldulensis* Dehnh. were selected from a stand at Khabat district (Askikalak) in Erbil Governorate, Kurdistan Region of Iraq. The stand lies at N 36° 15'; E 43° 38' and 252m elevation. It is 37 km away from Erbil city, and at the left side of Great Zab river. The total plantation area was about 138 hectares of pure *Eucalyptus camadulensis* Dehn.. The stand was established in fifteenth of last century by the Iraqi Government. In 1998 the stand project had been developed by FAO. Trees were planted (3×4) m spacing in a sandy loam soil,

Tree Selection, Marking, Felling, Bucking, and sawing:

On May 2011, *E. camaldulensis* trees were selected with a proper height, diameter, straightness, having no infection. They were 35-45 cm in diameter. Red paint on plain visible area above DBH was used for marking the selected trees. Ten of the marked trees were felled on June 2011. Felling was done by using chain saw by which limbing has been carried out, too.

Conditions of correct felling were maintained for insuring safe felling and no additional stresses to be obtained. The stem was topped at a diameter of 15 cm directly after felling; the end cut was painted by a proper paint to reduce moisture loss. Felling process for all marked trees was completed before starting subsequent operations. They were bucked to number of segments (logs) dependable on stem length.

Logs were picked up from the truck deck with fork lifter and placed on the table of vertical band saw. The logs were converted into sawn boards with different thicknesses using different sawing method according to treatment combination they were belonged.

Preparing of drying requisites

The study was conducted to deal with three prevailing wood drying methods (Air drying, solar drying, and kiln drying) to explore the possibility of drying *Eucalyptus camaldulensis* Denh. boards with minimum defects and maximum utility. Three stacks (one stack for each method) were prepared. Green boards dimensions were (Length: 2m, Thickness: 20, 40, and 60mm and Width: 32-202 mm).

Air drying: The air-drying yard was inside the fields of the Faculty of Agriculture and Forestry. It was constructed on gently sloping ground without growing weeds and well drained under the stack (concrete surface). Concrete blocks were used as a foundation (30cm height). The yard was in an open area, it was covered by iron shed to protect the boards from direct sunlight and precipitations. Direct sunlight of early morning hours could not be avoided, it had no damage effect. Boards were stacked in rows. Temperature and relative humidity were daily recorded, wood moisture content was weekly determined. Stack was placed in the stacking place and care was taken to align the stickers vertically. A sticker spacing of 750-850 mm was used; Uniform sticker thickness was used in accordance with good stacking practices. They were 15mm thickness, 30mm width and 2.25m length.

Solar drying: Solar Kiln was a modified greenhouse, with an arrangement to facilitate airflow through the stacks. It was 9.8m long , 8m wide, with an apex height of 3.5m, and oriented in a north –south direction. It was covered by double layer of polyethylene plastic. Two humidifiers (water nozzles) were positioned in the two corners of chamber facing each other. Also, setting of two vertical fans in order to ensure good air circulation inside the chamber. The only heat source was the solar heat gained from the direct sun light. To ameliorate temperature during hot days, a green plastic shed cover was employed to reduce sun light intensity.

Stacks were placed in the solar kiln chamber and care was taken to align the stickers vertically. To ameliorate temperature or changing humidity inside the kiln chamber, inlet-outlet fan, spraying nozzles' were started up for a certain time depending on the conditions of drying. Aeration through the two circulating fans was found to be necessary for attaining uniformity. It was noticed that during summer drying, high levels of temperature were recorded, especially at midday hours where the outer air temperature was at maximum. In such conditions aeration was not beneficially affected.

Temperature inside solar kiln was higher than outside. Therefore increasing humidity was obligatory. Water spraying could attain safe levels of humidity during first stages. After achieving the target moisture content by about four weeks, humidifying was stopped so RH substantially decreased and then it was dependable on climatic relative humidity. Eight weeks was enough for terminate the drying process. Additional period was given to boards for more stability. It might be

not necessary in practice. Although, the solar kiln was isolated from outer air changes, The conditions inside the kiln was strongly affected by sunlight radiation.

Kiln drying:

The compartment kiln was a modified incubator, 4.5m long, 2.5m wide, and height of 3m, though, insulation walls and roof was insured. It contained one loading door and supplied by axial flow fan 250 mm diameter for air inlet and outlet, two humidifiers (water nozzles) in the two corners of chamber facing each other. Also, it was supplied by two vertical fans in order to attain good air circulation through the chamber. Controlling the conditions inside the kiln was adjusted according to trial procedures by which using of one or more humidifier, one or two circulating fan, with or without ventilation was applied. The averages of air temperature, relative humidity, and wood moisture content (MC) were daily recorded starting from the first day until the end of drying process. Drying conditions inside the kiln were controlled following suggested drying schedule especially prepared on the basis of selected literature information. At first week of drying, air saturation was maintained, and then RH was decreased by about 10% for three weeks. It was kept over than 80% for another six weeks, and then gradual declining to 40% until drying was ended. Temperature was kept constant at 37 C˚ through all period proceeded the target wood MC, then it was declined to levels comparable to temperature of (outside kiln) interior conditions.

Testing and Analysis

Ten boards were chosen randomly by numbering all the boards and making random number election. The following drying characteristics were examined: Mean MC, Moisture gradient, Collapse, Bow, Cup, Twist, End split, Surface checks, Honeycomb, Case-hardening, and Discoloration. Testing methods were carried out according to (EDG, 1994) and (GOST, 2010).

Some tests were performed on the complete 2 m length boards; they were collapse, bow, twist, cup, surface checks, end split, and discoloration. Other tests were carried out after cross cutting the board at specific distances; they were, mean moisture content, moisture gradient, honeycomb, and casehardening.

The experiment was statistically analyzed as factorial CRD by using SAS program version (SAS, 2003)**.** Factors were: A: Drying method: 3 levels, B: Sawing method: 2 levels, C: Board thickness: 3 levels. Ten replications (boards)as blocks were tested for each of the 18 treatment combination. With few exception a total of 180 boards were invested for any of the properties studied. Statistical differences between treatment combination means were tested by Duncan Multiple Range test at 5% level (Duncan, 1955).

RESULTS AND DISCUSSION

Table (1): - Analysis of variance of drying properties as affected by drying method, board thickness, and sawing method during summer drying.

S.O.V.	D.F	Mean Square							
		Collapse	**Bow**	**Cup**	**Twist**	**End-split**	**Casehardening**	**Mean MC%**	**GM%**
DM	2	0.200	132.62*	12.217	426.42*	11578.4*	10.967*	74.448*	3.227*
Th.	2	2.867	538.22*	490.466*	45.005	5474.96*	0.822*	7.212*	7.667*
SM	1	1.467*	192.75	44.477*	349.256	20284.98	2.744	1.049	7.858
DM×Th.	4	67.222	66.005	2792.672	7.605*	379639.0*	0.0003*	0.002*	0.156*
DM×SM	2	10.555	221.94*	9.672	234.289	5120.00	0.034	0.0101	0.061
Th.×SM	2	5.755	86.54	496.021*	146.54	1625.02	1.243*	0.0404	0.027
DM×Th.×DM	4	24.889*	179.50*	64.176	54.422	19537.69	1.273*	0.028*	0.126

Table (2):- Mean values of collapse and bow as affected by drying methods, board thickness, and sawing methods:

Drying Method(DM)	Board Thickness (cm)	Collapse				Bow			
		Sawing Method (SM)		**DM×Th.**	**Mean of (DM)**	**Sawing Method (SM)**		**DM × Th.**	**Mean of (DM)**
		Flat	**Quarter**			**Flat**	**Quarter**		
Air	2	6.20	3.20	4.70	4.40 (a)	0.40	7.00	3.70	7.12 (a)
	4	4.40	4.40	4.40		3.20	10.50	6.85	
	6	4.60	3.60	4.10		13.3	8.30	10.80	
Kiln	2	3.60	4.80	4.20	4.30 (a)	0.90	3.50	2.20	6.53 (a)
	4	5.80	3.00	4.40		10.3	0.50	5.40	
	6	4.00	4.60	4.30		13.2	10.80	12.00	
Solar	2	4.80	5.00	4.90	4.40 (a)	1.20	3.30	2.25	4.30 (b)
	4	5.40	3.00	4.20		5.10	5.20	5.15	
	6	6.00	2.20	4.10		0.80	10.20	5.5	
Mean of (SM)		4.98 (a)	3.76 (b)	4.37		5.38 (a)	6.60 (a)	5.98	
Interactions				Mean of (Th)				Mean of (Th)	
Th.× SM	Th1	0.4.33	4.33	4.60 (a)		0.85	4.60	2.72 (b)	
	Th2	0.3.47	3.47	4.33 (a)		6.20	7.10	6.63 (a)	
	Th3	0.3.47	3.47	4.17 (a)		9.10	8.10	8.60 (a)	
DM× SM	A	0.5.07	3.73			5.63	8.60		
	K	0.4.47	4.13			8.13	4.90		
	S	0.5.40	3.40			2.37	6.20		

*Means having same letters are not significantly different according to Duncan's multiple ranges test at 5% level

Table (1) refers that only sawing method (SM) had significant effect on collapse, the other two factors and their interaction could not affect significantly. This factor (SM) when interacted with the other two, interactions showed high significant effects. Mean values of collapse (Tab. 2) indicate that moderate values of collapse have been obtained in almost all treatments. Accordingly, differences should be so small that they would not be enough to give statistical significances. Quarter sawn boards collapsed (3.76 mm) about one-third less than flat sawn boards (4.98 mm). Such amount of collapse could be removed by applying simple planning. Quarter sawing is slow and difficult, but it gave good results with problematic species like *Eucalyptus camaldulensis* Den. as (Yasin and Raza, 1992) stated. They explained that timber shrinks noticeably as it dries double the rate along the growth ring tangentially (Flat sawing) as it is perpendicular to the growth ring radially(Quarters-awing). Mostly with thinner boards, raises the chance of early-wood collapse. But (Wengert *et al.*, 2006) demonstrated that water moves faster in the radial direction than tangential direction or dries flat sawn board faster than quarter-sawn board for these reason flat sawn boards are more prone to develop collapse than quarter-sawn boards.

The three factors of the study were affected differently on bow (Tab.1). While board thickness showed high significant effects, drying method affected at lower level of confidence ($p<0.05$). Sawing method showed no statistical influences on bow. All interactions (except Th × SM) revealed high significant effects. Boards dried by air-drying possessed highest defect values (Tab.2). They bowed (7.12 mm) more than bow of solar drying (S), the lowest mean value of bow. Kiln drying showed values closer to that of air-drying than that of solar drying. While board thickness increased, bow values increased too. Thin boards (2 cm thick.) warped only by 2.72 mm, while thickest ones (6cm thick.) deflected from straight line by 8.60mm as a mean.

Although, quarter and flat sawing were not significantly different, it is noticeable that quarter boards had a few higher bow than flat boards. These results were in line with what has been found by (Read *et al*., 1974); (Sharma *et al*. 1974); (Gough, 1977). Bow and twist are those types of warping might be occurred because of spiral or diagonal grains and may be caused by the existence of bands of compression, tension, or juvenile wood that has abnormal longitudinal shrinkage (Simpson and TenWolde, 1999).

Table (3):- Mean values of cup and twist as affected by drying methods, board thickness, and sawing methods:

		Cup				Twist			
Drying (DM)	**Board Thickness (Th.)cm**	**Sawing M.(SM)**		**DM×Th.**	**Mean of (DM)**	**Sawing M.(SM)**		**DM ×Th.**	**Mean of (DM)**
		Flat	**Quarter**			**Flat**	**Quarter**		
A	2	17.40	0.00	8.70	4.60 (a)	16.10	12.50	14.30	8.72 (a)
	4	3.20	0.80	2.00		5.00	5.90	5.45	
	6	4.30	1.60	3.00		11.90	0.90	6.40	
K	2	14.20	0.50	7.40	3.80 (a)	5.60	3.20	4.40	4.15 (b)
	4	7.60	0.00	3.80		0.00	4.40	2.20	
	6	0.70	0.00	0.40		6.80	4.90	5.85	
S	2	12.40	0.80	6.60	4.70 (a)	0.00	2.40	1.20	4.05 (b)
	4	9.00	0.00	4.50		5.60	9.40	7.50	
	6	5.80	0.00	2.90		1.60	5.30	3.45	
Mean of (SM)		8.30 (a)	0.40 (b)	4.35		5.84 (a)	5.43 (a)	5.64	
		Interactions		**Mean of (Th)**		**Interactions**		**Mean of (Th)**	
Th.× SM	Th1	14.70	0.40	7.60 (a)		7.23	6.03	6.63 (a)*	
	Th2	6.60	0.30	3.40 (b)		3.53	6.57	5.05 (a)	
	Th3	3.60	0.50	2.10 (b)		6.77	3.70	5.23 (a)	
DM× SM	A	8.30	0.80			11.00	6.43		
	K	7.50	0.20			4.13	4.17		
	S	9.10	0.30			2.40	5.70		

Cup in board was affected by many factors in this study. (Tab.1) refers that thickness levels (Th) and sawing method(SM) had a highly significant effects on cups. While, the first factor (DM) did not effect significantly. Interactions showed no significant except that of board thickness by sawing method.

Quarter sawn boards behaved differently as compared with flat sawn boards. They showed higher stability concerning cupping. Overall mean of QSB (0.40%) was about 1/20 the cup of FSB (8.30%) (Tab.3). Among FSB, it is obvious that thinner boards warped more than thicker boards. Regardless to drying methods, the trend was the same when comparing mean values of the two sawing methods. Boards of (2 cm thick) had cup values 3.5 times the cup values of (6 cm thick). Therefore, maximum cup value (17.40%) has obtained for flat sawn, air-dried, 2 cm thickness boards. In opposite to that some treatment combinations under the column of QSB did not warp transversely i.e. (0%).

(Blakemore and Northway, 2009) who mentioned that tangential shrinkage is about double that in the radial direction, that means in back-sawn boards the drying stresses are supreme on the widest face. Therefore, distortions are more prone to happen on that face. Also, (Denig *et al.*, 2000) assured that flat sawn lumber has a higher tendency to cup during drying.

Level of significance showed high effects to drying method on twist (Tab.1). Similar level of confidence was obtained in case of (DM × Th.) interaction. Other two factors and interactions did not effect significantly.

Boards seasoned under uncontrolled conditions (air-drying) twisted (8.72mm). It is much more than boards dried by kiln or solar drying methods (Tab.3). These boards possessed their higher twist (16.10mm) when they were flat sawn and at minimum thickness (2 cm). As a mean of all thickness, flat sawn boards twisted by (11.00, 4.13, and 2.40 mm) for air, kiln, and solar drying respectively. The effect of board thickness on twist regardless to DM seemed to be non-significant although Th1 twisted (6.63 mm) little more than the other two means. Other treatments gave no clear effects since many other variables could have their influences. (Simpson and TenWolde,1999) declared that the presence of bands of compression, tension, and juvenile wood may cause twist that has abnormal longitudinal shrinkage.

Table (4):- Mean values of end split and Case-hardening as affected by drying method, board thickness and sawing method.

		End-split				Case-hardening			
Drying (DM)	**Board Thickness (Th.)cm**	**Sawing M.(SM)**		**DM×Th.**	**Mean of (DM)**	**Sawing M.(SM)**		**DM ×Th.**	**Mean of (DM)**
		Flat	**Quarter**			**Flat**	**Quarter**		
A	2	90.30	1.00	45.65	80.25 (a)	2.85	1.91	2.38	2.41 (a)
	4	112.70	61.70	87.20		2.15	2.35	2.25	
	6	177.90	37.90	107.90		2.25	2.92	2.59	
K	2	164.10	22.50	93.30	64.63 (a)	1.40	1.46	1.43	1.58 (c)
	4	91.80	13.40	52.60		1.87	1.53	1.70	
	6	47.00	49.00	48.00		1.52	1.72	1.62	
S	2	103.40	27.45	65.43	92.34 (a)	2.02	2.11	2.06	1.83 (b)
	4	174.80	59.80	117.30		2.17	2.21	2.19	
	6	163.00	25.60	94.30		1.21	1.26	1.24	
Mean of (SM)		125.00 (a)	33.15 (b)	79.07		1.94 (a)	1.94 (a)*	194	
		Interactions		**Mean of (Th)**		**Interactions**		**Mean of (Th)**	
Th.× SM	Th1	119.27	16.98	68.12 (a)		2.09	1.83	1.96 (b)	
	Th2	126.43	44.97	85.70 (a)		2.06	2.03	2.04 (a)	
	Th3	129.30	37.50	84.40 (a)		1.66	1.97	1.81 (c)	
DM× SM	A	126.97	33.15			2.419	2.396		
	K	100.97	28.30			2.09	1.83		
	S	147.07	37.62			2.06	2.03		

The obtained results (Tab.1) showed that only sawing method had highly significant effects on the end split. Other factors and their interactions showed no significant differences. Maintaining good protection procedures as end painting, log covering, good sticking, in addition to wood specific characteristics, might assisted in obtaining these results. Mean values (Tab.4) illustrated that the quarter sawn technique obtained a lowest rate of end split (33.15 mm) when compared with flat sawn technique (125.00mm).

It is known that shrinkage in tangential direction is about twice the rate of radial direction shrinkage (Nolan *et al.*, 2003). This truth is may be the reason made QSB more stable. The higher rate of shrinkage in QSB is across the shorter dimension of the board, while in FSB is across the longer board dimension.

In spite of non-significant differences between mean values of drying methods, kiln drying possessed lowest end-split among the three different methods. Increasing board thickness to 4 and 6 cm led the boards to have deeper end-split.

The method by which Eucalyptus wood boards were dried and thicknesses of boards were highly affected the property of casehardening (Tab.1). All interactions except one (DM×Th.) showed high levels of statistical effects. Air-dried boards had higher rates of casehardening (2.41 mm), while minimum mean (1.58 mm) was obtained from kiln-dried boards (Tab.5). The treatment combination (AD×Th6×QS) attained maximum casehardening (2.92 mm) but the lowest mean (1.21 mm) was attained by the combination of (SD×Th.6×FS**).** Here in, it is important to remind that stresses causing casehardening, should be not too large after conditioning, where EMC has ensured to the wood piece with the ambient.. In such cases, casehardening will be so small. (Fuller, 1955) recommended to reducing and get rid of casehardening, the board should conditioned to alleviate these stresses.

More than one factor affected mean MC%, (Tab.1). There were highly significant influences of drying method (DM) and board thickness (Th.) on mean of moisture content.

Table (5):- Mean values of Mean MC% and MC gradient as affected by drying method, board thickness, and sawing method.

		Mean MC%				MG%			
Drying (DM)	**Board Thickness (Th.)cm**	**Sawing M.(SM)**		**DM×Th.**	**Mean of (DM)**	**Sawing M.(SM)**		**DM ×Th.**	**ın of (DM)**
		Flat	**Quarter**			**Flat**	**Quarter**		
A	2	9.36	9.38	9.37		0.31	0.29	0.300	
	4	9.37	9.38	9.38	9.71 (b)	0.27	0.29	0.280	0.88 (a)
	6	10.35	10.43	10.39		1.95	2.16	2.05	
K	2	11.43	11.43	11.43		1.22	1.22	1.22	
	4	11.65	11.65	11.65	11.65 (a)	0.70	0.700	0.70	0.87 (a)
	6	11.84	11.88	11.85		0.72	0.69	0.71	
S	2	11.44	11.28	11.36		0.42	0.760	0.59	
	4	11.58	11.68	11.63	11.63 (a)	0.21	0.270	0.24	0.48 (b)
	6	11.91	11.92	11.92		0.62	0.57	0.59	
Mean of (SM)		10.99 (a)	11.00 (a)	10.99		0.71 (a)	0.77 (a)	0.74	
		Interactions		**Mean of (Th)**		**Interactions**		**Mean of (Th)**	
Th.× SM	Th1	10.75	10.69	10.72 (c)		0.65	0.76	0.70 (b)	
	Th2	10.87	10.90	10.88 (b)		0.39	0.42	0.41 (c)	
	Th3	11.36	11.41	11.38 (a)		1.10	1.14	1.12 (a)	
DM× SM	A	9.69	9.73			0.84	0.91		
	K	11.64	11.65			0.88	0.87		
	S	11.64	11.62			0.42	0.53		

Air-drying showed the lowest rate of MC (9.71%) among the three methods (Tab. 5). Solar drying and kiln drying boards had similar rate of MC, they were (11.63% and 11.65%) respectively. Interaction between these two factors (DM and Th) showed significant effects, too. The third factor (SM) did not show such effects. Boards dried under controlled and semi controlled conditions i.e. kiln and solar drying retained more MC than air-drying. Differences was about (2%) MC. With increasing of board thickness, moisture content was slightly increased. The lowest mean

MC (9.37%) was in boards of (2 cm) thickness and air-dried. Comparing mean values of different board thicknesses supports the conclusion that thickest boards although conditioning retain higher content of moisture.

Factors affected mean MC was the same, which had significant effects on MC gradient (Tab.1). Since mean MC refers to the average of moisture content of all boards layers, it should have a direct relation to moisture of shell and that of core, or the difference between them (MG).Solar drying method had the lowest gradient among the three. (5 cm) thickness boards of the method possessed minimum gradient value (0.24%), while the maximum (2.05%) was for air-dried (6 cm) thickness boards. In conditioning, all boards stayed under same condition for the same period, so some unexpected values might obtain because of the wood variability and other unknown experimental reasons. Mean of all (6 cm thick.) board gradients (1.12%) was more than that of thinnest boards by about (0.42%). All values of MG for treatments and their combinations were too small and stayed within the boundaries of wood specifications.

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پوختە

ڤەکولین لسەر جوریّ *Eucalyptus camaldulensis Dehnh.* ژ بو زانینا کێرهاتنا وی ژبو دەپین داهێنانکری. دەه دارهاتنە برین وداهێنانکرن ژبو چێکرنا دەپان ژبو تاقیکرنا کارتێکرنا سیّ ریّکین هشککرنیّ ودوو شیّوازین داهێنانی‌ و سیّ ستویراتین دەپا. تاقیکرنا جوراتییّ بو خرابین دەپا کو بوهەر ئێکیّ *360* دەپ هاتبونە بکارئینان . ئەنجمین ڤەکولینیّ داکوکی لسەر ڤیّ چەندیّ کر کو هەرفین، وەربادان (چەمان ، خار وڤیچ) و تیکبونا دوماهیکیّ کارتێکرنا وان برەنگەکیّ بەرچاڤ ب شیّوازین داهێنانیّ کر بو، هەروەسا ئاستیّ ئێکیّ ژ ستویراتییا دەبا کارتێکرن دگەل چەمانیّ هەبو. دیار بو کو ریّکین هشکرکرنیّ فاکتەریّ ئێکانە بو لسەر ڤیچبونیّ، ئەڤە و ریّکێن هشککرنیّ دگەل ستویراتییا دەپا کارتێکرنا پێشچاڤ لسەر تێکرا و ریّزبەندییا شهیّ. هەلسەنگاندنا خرابین دەپێن داهێنانکری داکوکی لسەر بکێر هاتناجوریّ ناڤبری بو پیشەسازییا دەپین داهێنانکری هەیە.

الخلاصة

اجريت الدراسة على النوع .*Eucalyptus camaldulensis Dehnh* للبحث في صلاحيته للاخشاب المنشورة. تم قطع عشر اشجار ونشرها الى الواح ودراسة تأتير ثلاث طرق للتجفيف وطريقتين للنشر، وثلاث سماكات للوح. كان اختبار النوعية تبعا للعيوب التي درست بواقع *180* لوح لكل صفة (عيب). اكدت النتائج ان كلا من التجعد والتقعر والتشقق الطرفي قد تأثر بصورة رئيسة بطريقة نشر اللوح، في حين كانت سماكة اللوح العامل الاول في التأثير على التقوس. وظهر ان طريقة التجفيف هي العامل الوحيد المؤثر في الالتواء، وهذه (طريقة التجفيف) مجتمعة مع سماكة اللوح أثرا معنويا على كل من المعدل والتدرج الرطوبيين. ان تقييم العيوب للالواح المنشورة اكد صلاحية النوع المذكور لهذه الصناعة.

TESTING OF WINTER DRYING DEFECTS ON *Eucalyptus camaldulensis* Dehnh. SAWN-BOARDS

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ABSTRACT

The possibility of using *Eucalyptus camaldulensis* Dehnh. as sawn wood was investigated by felling 12 trees and sawing the main stem into 3 thicknesses boards. Three methods of drying were applied (Kiln, Solar, and air drying) in winter. The effect of girdling the standing tree was tested too. Drying defects were examined and boards accordingly were qualified. Results showed that drying method and board thickness affected each of end split, mean MC%, MG% and casehardening. While bow was affected by the method of drying, collapse and twist were mainly influenced by board thickness. Girdling showed no significant effects supporting its application as improving procedure. Degrees of drying defects assured the validity of winter drying procedures for producing merchantable quality sawn-boards from the studied species.

KEY WARDS: Drying defects, *E. camaldulensis*, Board properties, Winter season

INTRODUCTION

Kurdistan Region of Iraq is a habitat of wide range of tree species belonging to both groups; broad leaves and conifers. Natural forests are distributed over the areas where conditions are favorable, they were subjected to a tragically circumstances through the second halve of last century. Although, the status has eventually improved, it is still so far from satisfying requirements of sustainable management. Practically, no planning for forest utilization is applying neither for natural forests nor for plantations in the region.

Wide areas-among big project of forestation were planted in Iraq since the mid of last century where *Eucalyptus* was the predominant species. Some of plantations were established in Kurdistan region. Unstable political and economical circumstances before 2003 led to sever deterioration of these plantations. Currently, serious efforts are exerting for establishing a new forestation projects either by Eucalypt or by other species.

Genus *Eucalypust* has more than 600 species and varieties. Those cultivated due to the commercial standards, do not exceed a dozen of its kinds. *E grandis* and *E.globulus* species are predominant in fast grown plantation (Acusta *et al.,* 2008). They are widely used for a variety of products like sawn timber, mine pros, poles, fire wood, pulp, essential oils, furniture, honey, tannin, shade and shelter, soil reclamation, construction purposes, wind break, pest resistance, and natural landscaping (Eldridge *et al*.,1993).

Range of distribution of the genus is extended from tropical to subtropical and warm temperate, and from arid to semi arid regions. It tolerates temperature from 3 to 5 C° in winter and in dry season it tolerates (34-45 °C) four to eight month or more and even more severe temperatures. Frosts are rare (5–20 days per year) according to (Mariani *et al.*, 1981).

In Iraq, Eucalypt has been introduced to the country as an exotic tree during the last century. The two main species were *E.camaldulensis* and E. microtiheca, some other species as *E.largiflorens, E. sideroxylon,…etc.* were planted in an experimental attempts and till now could not be considered as established species (Rooitzsch and Reader,1969). Main uses were pulp production, chipboard, fire wood, shelter belts… etc. In the middle and southern part of country, where a significant levels of high temperature are predominant in summer, the species could stand well and resist the sever drought conditions. Proper temperature and humidity rates as well as precipitation in Kurdistan offered better conditions for Eucalypt in summer. The situation is different in winter; it is not advisable to plant it at high elevations

*A part of the second author's thesis.

where long period of frost is expected during the season. Such sever conditions Eucalypts cannot resist (FAO, 1981).

Forestry officials reports referred that the main two species of Eucalypt in Iraq *E.camaldulensis* and E. microtiheca were planted in Kurdistan at an elevations of 400 - 800 meters . The area of Eucalypt plantations was about 3000 hectare in 70th of last century (FAO, 1979). But the current estimations are about14000 hectare (MoA in KRG, 2012)* .

E.camaldulensis is the main species of artificial forestation in the country till the moment. The species is attending in about almost all Iraqi territories. At higher elevations of Kurdistan the growth slows down or inhibits as a result of periodic sever frost. At other elevations it is doing well.

The lack of industrializing wood products in Iraq, so in Kurdistan Region makes it difficult to have clear idea about the possibility of Eucalypt utilization. It is well known that environmental conditions could have main effects on the wood properties, and because of the scarcity of studies dealing with eucalypts wood in Iraq especially those related to its drying, this study has planned to search in possibility of utilizing the species grown in Kurdistan for sawn board industry by drying them in winter. Accordingly, the main objects of the study were to find out the suitable method of drying and testing the effects of board thickness and tree girdling on board quality.

Materials and Methods

Twelve trees of *Eucalyptus camaldulensis* Dehn. were selected from a stand at Khabat district (Askikalak) in Erbil Governorate, Kurdistan Region of Iraq. The stand lies at N 36° 15'; E 43° 38' and 252m elevation. It is 37 km away from Erbil city, and at the left side of Great Zab river. Trees were planted (3×4) m spacing in a sandy loam soil. Monthly averages of climatic conditions for the last ten years were as follows: Maximum temperature was in July (33.2 C°), minimum temperature in January (8.3 C°). Highest relative humidity was in January (78.7 %) and lowest in August (41.6%). Precipitation was at maximum average in February (68.2mm) and minimum in June & August (0.00mm), (Metrological Station-Erbil 2012) .

The trees were marked, felled in date according to plan, and bucked into 2m length logs until merchantable diameter, limbed, Measured (weight and volume) at stumpage area with carful performances on logs for safety. Protection procedures were applied to prevent quick moisture loss. Then logs were transferred to saw mill for board sawing. Logs were sawed into three thicknesses boards by quarter sawing . All board dimensions were measured, moisture content and specific gravity were determined too.

Tree Girdling

Trees were divided into two groups; the first six trees were remained without treatment, the other six were subjected to girdling. A complete strip of the bark (10 cm wide) was removed two months before felling to let trees die while standing. It was an attempt for reducing growth stresses.

Preparing of drying locations required a construction of solar kiln, furnishing of compartment kiln and preparing of air seasoning yard. Equal volumes of sawn boards represented 18 treatment combinations were stacked regularly for drying under conditions of each of the three methods.

The open air climates of winter were the conditions under which air drying was performed. In kiln drying, temperature, relative humidity, and aeration were controlled following a specially prepared drying schedule. For solar kiln, drying conditions were partially controlled by aeration and water spraying.

The kiln was established in Sumeil, at the Faculty of Agriculture and Forestry /University of Duhok. It was a modified incubator, 4.5m long, 2.5m wide, and height of 3m, so insulation walls and roof was inssured. It contained one loading door and supplied by axial flow fan 250 mm diameter for air inlet and outlet, two humidifiers (water nozzles) in the two corners of chamber facing each other. Also, it was supplied by two simple vertical fans in other two corners of chamber facing each other in order to attain good air circulation through the chamber.

Controlling the conditions inside the kiln was adjusted according to trial procedures by which one or more humidifier, one or two circulating fan, with or without ventilation water tested. Temperature and relative humidity were recorded through minute's intervals for each combination of the above variables. Procedure was repeated many times until having the key by which increasing or decreasing temperature or relative humidity within certain limits and reasonable efficiency was obtained. Digital hygrometer, thermometer, as well as thermograph were used for the purpose.

Stacks were placed in the solar kiln chamber and care was taken to align the stickers vertically. The sticker thicknesses were in accordance with good stacking practices, and having the same dimension of that of air and kiln drying. To ameliorate temperature or changing humidity inside the solar kiln chamber, inlet-outlet fan, spraying nozzles' were started up for a certain time depending on the conditions of drying. Aeration through the two circulating fans was found necessary for attaining uniformity. In air drying, lumber stacked properly to insure adequate air circulation and protection the stack from direct sun light and precipitations. The yard has constructed on gently sloping ground and well drained under the stack. Concrete blocks were used as a foundation (30cm height). Then bottom support (three wooden bunk) acted as the base of stack (Length: 2.5m, Width: 1.2m, Height: 1.71m, Layers of boards: 30) each layer contained boards of same thickness and length. Stack was placed in the stacking board yard and care was taken to align the stickers vertically. Sticker spacing was 750-850 mm; the stickers were made from dried wood of *Populus nigra* .Uniform sticker thickness was used in accordance with good stacking practices. They were 15mm thickness, 30mm width and 2.25m length. Air seasoning yard was at an open area inside the fields of the Faculty of Agriculture and Forestry.

At the end of drying period, boards stayed under the indoor conditions until equalizing has been attained.

Assessment of drying defects was accomplished in accordance with reliable procedures of specific International Standards. Each one of drying defects was determined by examining of ten boards for each of the 18 treatment combinations. Data were analyzed statistically as CRD factorial experiment with three factors; drying method (3-levels), Board thickness (3-levels), and girdling (2-levels). Comparison of treatment means was done by multiple range test **(**Duncan, 1955).

Results and Discussions

Table (1): Analysis of variance of drying properties as affected by drying method, board thickness, and sawing method during summer drying.and girdling operation during winter season.

S.O.V.	D.F	Mean Square							
		Collapse	Bow	Cup	Twist	End-split	Casehardening	Mean MC%	GM%
DM	2	00.404	271.85*	34.739	84.672	5758.96*	0.911*	121.375*	25.936*
Th.	2	18.010	37.516	2836.439	362.40*	5964.239*	5.426*	549.030*	159.259*
SM	1	4.665	38.292	2072.997	99.847	3865.656	2.412	21.959	9.398
DM×Th.	4	1.663	7.605	2347.222	77.355*	352.800	0.020*	6.242*	1.058
DM×SM	2	0.369	20.372	380.572	82.405	13180.46*	0.493*	4.279	0.968
Th.×SM	2	4.420	14.005	291.539	40.939	408.817	0.228*	4.896	0.748
DM×Th.×DM	4	2.046	84.447	978.614	81.664	2453.533	0.445*	3.339	1.087

From all factors, only one (board thickness) showed little effects (P< 0.05) on collapse (Tab.1). The result was quite similar to that of summer season (Tab.2) where only sawing method (the excluded factor) had significant effects. The obtained small collapse values resulted in obtaining smaller variations. This reason could interpret the non-significant effects.

Observing (Tab.2) gives impression that about all boards behaved similarly in regard of collapse. Thinner boards showed mean collapse about three quarters the overall mean. Minimum collapse (1.29mm) was obtained in case of combination of Th1 with G+. The use of mild drying conditions leads to having honeycomb free boards, the main reason of severe collapse.

The results were not in line with those obtained by (Kantay, *et al*, 2002) who found that the *Eucalyptus* was prone to collapse easily and was observed in different thickness levels especially in both the low board thickness and more board width.

Wile, some authors attributes the propensity to collapse to the weakness of parenchyma wall or thin-walled fibers, other authors tried to link the tendency to collapse with the species density (Santos, 2002*)*.

Drying method was the only factor that affected bow at high significant levels (Tab.2). The interaction between the three factors together was appeared at lower level of significance. All other factors and theirs interactions could not affect bow at accepted level of confidence.

Boards dried direct weather changes (air-drying) suffered much more than boards protected from these changes (kiln and solar drying). About 1/3 the bow of air-dried boards could be avoided by using kiln drying. Solar method was closer in results to kiln than of air-drying.

As with collapse, girdling did not reflect any influences on bow. The treatment combination of (G+ x KD x Th2) gave minimum mean of bow (5.80 mm).

Table (2): Mean values of collapse and bow as affected by drying methods, board thickness, and girdling operation:

		Collapse				Bow			
Drying (DM)	Board Thickness (Th.)cm	Girdling O. (GO) No-G.	Girdling	DM ×Th.	Mean of (DM)	Girdling O. (GO) No-G.	Girdling	DM × Th.	Mean of (DM)
A	**2**	**0.78**	**1.49**	**1.14**		**12.30**	**13.50**	**12.90**	**12.00 (a)**
	4	**3.17**	**1.94**	**2.56**	**2.13 (a)**	**11.30**	**11.80**	**11.55**	
	6	**2.50**	**2.90**	**2.70**		**12.40**	**10.70**	**11.55**	
K	**2**	**1.25**	**1.96**	**1.61**		**8.20**	**7.50**	**7.85**	**7.62 (b)**
	4	**3.13**	**2.47**	**2.80**	**2.17 (a)**	**8.80**	**5.80**	**7.30**	
	6	**2.41**	**1.81**	**2.11**		**7.00**	**8.40**	**7.70**	
S	**2**	**1.84**	**1.53**	**1.68**		**7.40**	**6.40**	**6.90**	**8.43 (b)**
	4	**1.88**	**1.63**	**1.76**	**2.01 (a)**	**7.10**	**7.80**	**7.45**	
	6	**2.85**	**2.35**	**2.60**		**9.10**	**12.00**	**10.95**	
Mean of (GO)		**2.20 (a)**	**2.01 (a)**	**2.10**		**9.29 (a)**	**9.41 (a)**	**9.35**	
	Interactions			Mean of (Th)					Mean of (Th)
Th. × GO	**Th1**	**1.29**	**1.66**	**1.48 (b)**		**9.30**	**9.13**		**9.21 (a)**
	Th2	**2.73**	**2.01**	**2.37 (a)**		**9.07**	**8.47**		**8.77 (a)**
	Th3	**2.59**	**2.35**	**2.47 (a)**		**9.50**	**10.63**		**10.06 (a)**
DM × GO	**A**	**2.15**	**2.11**			**12.00**	**12.00**		
	K	**2.26**	**2.08**			**8.00**	**7.23**		
	S	**2.19**	**1.84**			**7.87**	**9.00**		

Climatic conditions through winter seamed to have their vital effect in decreasing wood defects among the study. Small rate of warping resulted in small variations between treatments.

As regards to girdling, these results do not agree the findings of (Giordano, *et al.*, 1969) and (Giordano and Currò, 1973) and their recommendation to make girdling before felling or crosscutting the trees of *Eucalyptus camadulensis* Denh**.** to reduce about 50% of deformations. Girdling in this study did not improve bow deformation.

Warping can be minimized by applying good stacking and piling, appropriate sawing applying make boards with steady thickness, so as to desirable quality for stacking and drying regularity (Simpson, and TenWolde, 1999).

Table (3): Mean values of cup and twist as affected by drying method, board thickness, and girdling operation during 2012 season.

		Cup				Twist			
Drying (DM)	Board Thickness (Th.)cm	Girdling O. (GO)		DM ×Th.	Mean of (DM)	Girdling O. (GO)		DM × Th.	Mean of (DM)
		No-G.	Girdling			No-G.	Girdling		
A	2	0.900	0.740	0.820	1.962 (a)	13.10	8.90	11.00	6.38 (a)
	4	2.300	1.150	1.725		10.80	2.70	6.75	
	6	3.600	3.080	3.340		1.00	1.80	1.40	
K	2	1.300	2.720	2.010	1.810 (a)	3.60	7.30	5.45	4.12 (a)
	4	0.700	0.940	0.820		6.10	1.80	3.95	
	6	3.800	1.400	2.600		4.00	1.90	2.95	
S	2	3.750	1.900	2.825	1.792 (a)	6.40	6.90	6.65	4.63 (a)*
	4	1.620	0.200	0.910		1.60	4.50	3.05	
	6	1.880	1.400	1.640		4.70	3.70	4.20	
Mean of (GO)		2.206 (a)	1.483 (a)	1.844		5.70 (a)	4.39 (a)	4.94	
Interactions				Mean of (Th)				Mean of (Th)	
Th. × GO	Th1	1.983	1.787	1.855 (ab)		7.70	7.70	7.70 (a)	
	Th2	1.540	0.763	1.152 (b)		6.17	3.00	4.58 (b)	
	Th3	3.093	1.960	2.527 (a)		3.23	2.47	2.85 (b)	
DM × GO	A	2.267	1.657			8.30	4.47		
	K	1.933	1.687			4.57	3.67		
	S	2.417	1.167			4.23	5.03		

*****Means having same letters are not significantly different according to Duncan's multiple ranges test at 5% level.

While, cup of some treatment combinations did not exceed (0.2%), others had (3.8%). Although non-significant, (Tab.3) shows that boards of trees subjected to girdling concaved lesser than boards without girdling. The effect of board thickness was dependable on drying method.

In general, thickest boards had the highest cup mean values (2.53%). This defect is thought to be because of tree's shrinkage anisotropy than stacking faults. In addition to cell orientation, radial/ tangential differences, presence of tension and juvenile wood, cup can be caused by board position in stem, thickness and width and direction of cut. Many or all of these factors, most probably, lead to have these variations.

The obtained results referred to the reasonable rate of cupping which might be less than the degree demonstrated (Kantay, *et al*, 2002).

The thickness of the board as a factor appeared to reveal the highest effect on twist in this test (Tab.3). The interaction of this factor with drying method was significant too, but at lower statistical level. As board thickness increased, twist has decreased. Shows (Tab.3) that thinnest board, as a mean, twisted (7.70mm) about three times as thickest boards (2.85mm). Air-dried boards warped more than boards of the other two methods. Girdling minimized twist by about (1.30 mm) as a mean. Maximum twist was (13.1 mm), it has been recorded by treatment combination of air-drying× girdling×2 cm thickness boards.

The main causes of twist are the cell orientation not being parallel to the longitudinal axis of a board, radial/tangential differences, longitudinal shrinkage of tension or juvenile wood, and release of growth stresses (Vermaas, 2002). Although, all of these these factors can influence warping of wood, none of them revealed substantially effects that could lead to high rates of twist.

Table (4): Mean values of end split and Casehardening as affected by drying method, board thickness, and girdling operation during 2012 season.

		End-split				Casehardening			
Drying (DM)	Board Thickness (Th.)cm	Girdling O. (GO)		DM×Th.	Mean of (DM)	Girdling O. (GO)		DM ×Th.	Mean of (DM)
		No-G.	Girdling			No-G.	Girdling		
A	2	45.00	0.00	22.50	24.27 (ab)	1.58	1.61	1.55	1.5 (c)
	4	18.70	24.60	21.65		1.91	2.16	2.03	
	6	45.20	12.10	28.65		1.21	0.87	1.04	
K	2	0.00	39.10	19.55	27.63 (a)	1.40	1.76	1.582	1.59 (b)
	4	0.00	15.00	7.50		1.50	1.58	1.537	
	6	31.00	80.70	55.85		1.63	1.70	1.662	
S	2	17.40	14.20	15.80	9.23 (b)	2.15	2.14	2.149	1.78 (a)
	4	7.70	0.00	3.85		2.29	1.71	2.00	
	6	5.80	10.30	8.05		1.18	1.20	1.19	
Mean of (GO)		18.98 (a)	21.78 (a)		20.37	1.65 (a)	1.63 (a)		1.64

	Interactions			Mean of (Th)			Mean of (Th)
Th. × GO	Th1	20.80	17.77	19.28 (ab)	1.713	1.838	1.77 (b)
	Th2	8.80	13.20	11.00 (b)	1.902	1.815	1.86 (a)
	Th3	27.33	34.37	30.85 (a)	1.336	1.257	1.29 (c)
DM × GO	A	36.30	12.23		1.568	1.546	
	K	10.33	44.93		1.507	1.679	
	S	10.30	8.17		1.876	1.683	

Two of the three factors were affected this type of defects. Drying method and board thickness appeared significant levels of influences, while the third (girdling) did not show such effects (Tab.1). Among four interactions, only one (the interaction of DM x G+) was at high significant levels.

Results in (Tab.4) confirm that this property was highly improved as compared with summer drying. Thickest boards splited more than others.The results were agreed that of (Denig *et al.*, 2000) who demonstrated that the thicker the lumber, the longer the drying time and the more difficult it is to dry without creating defects.

Kiln dried boards, in unexpected results; showed higher end-split mean value (27.63mm). While, the combination of (K x Th3 x G+) showed highest split, some treatment combinations showed no splitting at all. In addition, girdling could not improve the property.

Improper drying , growth stresses due to their fast rate of growth, presence of wide wood rays are effective reasons for end splitting, therefore, in all hardwoods to controlling end splits, boards are ought to be end coating before drying (Muller, 2011). The thicker the lumber, the longer the drying time and the more difficult it is to dry without creating defects(Denig *et al.*,2000).

Values of casehardening confirmed that accepted levels of stresses arisen after drying (Tab.1). Solar drying showed the highest (1.78mm) and air drying the lowest (1.54mm) casehardening (Tab. 4) . Boards of Th3 appeared better casehardening than the other two thicknesses. Treatment combination of (AD x Th3 x G+) gave best casehardening mean value (0.87mm).

The moderate stresses resulting from these moderate casehardening could not be enough to originate additional sever defects, as other tests showed. The overall mean (1.64 mm) and normal values distribution around the mean assured that stable boards were obtained although some of treatment combinations exceeded (2 mm) of casehardening. The impervious structure of hardwoods encourages greater moisture gradients, as result in more severe casehardening as (Muller, 2011) explained, the moderate casehardening we obtained might be a result of elongation of drying period for an additional time.

Table (5): Mean values of MC gradient and MG as affected by drying method, board thickness, and girdling operation.

		Mean MC%				MG			
Drying (DM)	Board Thickness (Th.)cm	Girdling O. (GO)		DM ×Th.	Mean of (DM)	Girdling O. (GO)		DM × Th.	Mean of (DM)
		No-G.	Girdling			No-G.	Girdling		
A	**2**	8.73	8.60	8.66	10.28 (c)	0.28	0.26	0.27	1.02 (b)
	4	9.83	9.83	9.83		0.78	0.78	0.78	
	6	13.68	11.06	12.37		2.66	1.34	2.00	
K	**2**	8.50	8.50	8.50	11.98 (b)	0.77	0.77	0.77	2.14 (a)
	4	12.35	11.75	12.05		1.56	1.44	1.50	
	6	15.62	15.18	15.40		4.09	4.19	4.14	
S	**2**	9.39	9.69	9.54	13.11 (a)	0.31	0.32	0.31	2.17 (a)
	4	12.68	12.82	12.75		1.57	1.55	1.56	
	6	17.04	17.05	17.04		4.65	4.64	4.64	
Mean of (GO)		11.98 (a)	11.61 (a)		11.79	1.85 (a)	1.70 (a)		1.77
	Interactions				Mean of (Th)				
Th. × GO	**Th1**	8.87	8.93		8.90 (c)	0.45	0.45		0.45 (c)
	Th2	11.62	11.47		11.54 (b)	1.30	1.26		1.28 (b)
	Th3	15.45	14.43		14.94 (a)	3.80	3.39		3.59 (a)
DM × GO	**A**	10.75	9.83			1.24	0.79		
	K	12.16	11.81			2.14	2.13		
	S	13.04	13.18			2.18	2.17		

Drying method, board thickness and their interaction affected significantly the moisture content of the boards (Tab.1). Girdling and other interactions did not influence statistically.

Solar dried boards retained maximum MC. They possessed about (30%) of moisture higher than air-dried boards (Table 5). Kiln drying was in between these two methods. Board thickness was the most effective factor. The relation was direct positive relationship. As board thickness increased, moisture content increased too. Board of (6 cm) thickness reserved (14.4%) moisture content. While, thinnest ones had only (8.9%) MC.

The factors affected MG were the same that affected mean MC and was quite the same levels of significant (Tab.5). Only the first two factors DM, Th. and their interaction were at high significant level. There is, of course, intimate relation between mean MC and MG where the first means the average MC of all wood piece layers, and the second, refers to the difference in MC between surface and core layers. The gradient in moisture content was at its lower rate

with air-dried boards (Tab. 5), that because they had the lowest mean of moisture content (Tab. 5). These boards were exposed to climatic conditions made them at moisture content lower than indoor EMC.

Board thickness strongly affected MG. As average, MG of (Th1, Th2, Th3) was (0.45%, 1.28%, and 3.59%) respectively. This relation was more convenient in solar drying when thickest boards had about 15 times the gradient of thinnest boards. Girdling could not improve MG at accepted levels of confidence. Lowest MG (0.26%) was obtained by (AD x Th1 x G+), while highest MG (4.65%) was in combination of (SD x Th3 x G-).

Values of casehardening confirmed that accepted levels of stresses arisen after drying (Tab.1). Solar drying showed the highest (1.78mm) and air drying the lowest (1.54mm) casehardening (Tab. 5). Boards of Th3 appeared better casehardening than the other two thicknesses. Treatment combination of (AD x Th3 x G+) gave best casehardening mean value (0.87mm).

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پوختە

ڤەکولین لدور شیانێن بکارئینانا دارین یوکالیپتوسێ ژ بو دەپین داهێنانێ هاتنە کرن کو12 دارهاتنە برین و وقورمێ سەرەکی داهێنا ژبو سێ ستویراتیا. سێ ڕێکین هشککرنێ (هشککرنا تەنویرێ، خانیێ پلاستیکی، و سروشتی) ل وەرزێ زڤستانێ هاتنە بکارئینان. هەروسا ڤەکولین لسەر کارتێکرنا کریارا تیڤلکرنێ بو دارین زندی ژبودیارکرنا کێرهاتنێ دتاقیکرنین کو بڕێکا پشکنینا خرابین هشککرنێ ین جوراجور. ئەنجاما دیارکر کو ڕێکین هشککرنێ وستویراتیا دەپا برەنگەکێ مەزن کارتێکرن لسەر تیکێن برەخیڤە، تێکراییا شهیێ و ڕێزبەندییا شهیێ و ڕەقبونا سەرڤە هەبو. بەڵێ خواربونا دەپا کارتێکرن لسەر هاتبو کرن ب ڕێکێن هشککرنێ، ستویراتییا دەپا کارتێکرن لسەر هەرفین ووەربادانێ تومارکر. کریارا تیڤلکرنێ چو کارتێکرنین پێشچاڤ دپشتەڤانیا بکارئینانێ ژبو باشکرنا جوری دیارنەکر. ڕێژا خرابیین هشککرنێ دووپات لسەر ب دەستڤەئینانا جورەکێ پەژراندنێ ژ دەپێن ل زستانێ هاتینە هشککرن و بەرهەمهاتی ژ جورێ ڤەکولین لسەر هاتیە کرن.

الخلاصة

تم البحث في امكانية استخدام اشجار .*Eucalyptus camaldulensis* Denh للالواح المنشورة باسقاط 12 شجرة ونشر جذوعها الرئيسة الى الواح بثلاث سماكات. استخدمت ثلاث طرق للتجفيف (تجفيف الفرن، التجفيف الشمسي، التجفيف الهوائي) وذلك خلال فصل الشتاء. وتم البحث ايضا في تأثير عملية تحليق الاشجار الواقفة عل صلاحية الالواح التي اختبرت عن طريق فحص عيوب التجفيف المختلفة. أشرت النتائج الى ان طريقة التجفيف وسمك اللوح قد اثرا بشكل كبير على كل من التشقق الطرفي، المعدل الرطوبي، التدرج الرطوبي، والتصلب المحيطي. وبينما تأثر التقوس بطريقة التجفيف، أثرت سمك الوح على كل من التجعد والالتواء. لم تظهر عملية التحليق تأثيرا يدعم استخدامها كاجراء لتحسين النوعية. لقد اكدت درجات عيوب التجفيف الحصول على النوعية المقبولية من الالواح المجففة شتاء والمنتجة من النوع المدروس.

PHYSIOLOGICAL STUDIES ON GROWTH ANALYSIS, YIELD AND YIELD COMPONENTS OF MUNGBEAN (*Vigna radiata* (L.) Wilczek) UNDER VARYING INTERVALS OF IRRIGATION AND ROW SPACING

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ABSTRACT

This experiment was conducted at the Agricultural Research Station/Salahaddin University/Erbil, during summer 2012 in order to study the effect of two irrigation intervals (every 5 days and every 10 days) and three row spacing (10 × 20, 10 × 30 and 10 × 40 cm) on physiological growth analysis such as leaf area index, leaf area ratio, relative growth rate, net assimilation rate, yield and its components and water use efficiency of mungbean. Experimental design used was RCBD with split plot arrangements and the main plot consisted of two irrigation intervals, while three row spacing were kept in sub-plots. Physiological growth measurements, yield and its components varied significantly due to variation in irrigation interval, row spacing and their interaction. The every 5 days irrigation, 10 × 40 cm spacing and interaction of irrigation every 5 days with 40 cm produced the highest values in most of these characters based on individual plant, while irrigating every 5 days with 10 × 20 cm spacing produced the highest seed yield per unit area (321.18 g/m^2) in addition to water use efficiency, which can be the optimum treatment combination for maximum yield of mungbean under summer conditions of Erbil.

KEY WORDS: *irrigation interval, row spacing, physiological growth analysis, seed yield, water use efficiency, mungbean.*

INTRODUCTION

Mungbean is a short duration legume crop cultivated primarily for their dry seeds, often called green gram in international publications. Like most legumes, mungbeans have great value as food, fodder and green manure. In addition to improving the soil fertility, it is a cheap source of protein for direct human consumption. Chemical analysis of mungbean seed indicates that it contains 20-24% protein, 2.1% oil, 1-2% fats, carbohydrates and a fair amount of vitamin A and B (James, 1981).

The difference in irrigation levels and planting density is the great importance for the yield, its components and growth analysis measurements. As for as available literature is concerned, no any extensive work has been carried out about the effect of these factors on mungbean in Iraq; the varying time of irrigation had significant effect on yield and yield components. No irrigation at the flowering stage, reduced number of pods/plant, number of seeds per pod and seed yield, while withholding irrigation at the pod filling stage decreased 1000-seed weight (Sadeghipour, 2008). Irrigation can be conserved and yields maintained by using appropriate irrigation timing to avoid plant water stress at critical growth stages (Norwood, 2000). Haqqani and Pandey (1994) stated that mungbean suffering water stress resulted in decreased seed yield, pod number, number of seeds/pod and 1000 seed weight. Flowers appeared earlier in plants irrigated every 5days than plants watered every 10 days. Plants of watered every 15 days, flowered later and produced fewer flowers than mungbean watered every 15 days (Sheteawi and Tawfik, 2007). Nabizade et al. (2011) found the best yield cultivar associated with the seven-day irrigation (3328 kg/ha) was. And most of the biological function associated with a 7 day gem varieties and irrigation amount was 9273 kg/ha maximum harvest index to local varieties and 10 days irrigation amount was 49 percent. There are large differences in yield among the mungbean varieties (Ahmad *et al.*, 2003) and the maximum potentiality can be achieved from the optimum spacing. Row planting with appropriate planting density can help to ensure optimum plant population/unit area of mungbean increasing the yield. Ahamed *et al.* (2011) report that the plant spacing 20×10 cm produced the highest (1044.03 kg/ha) and 40×10 cm produced the lowest yield (621.97 kg/ha). Ihsanullah *et al.* (2002) reported that 20 cm row-to-row spacing with 15 cm plant-to-plant can be recommended for irrigated condition to get higher yield in mungbean.

On the other hand, plant morphological characteristics and yield-forming components must be better understood if maximum yields are to be realized and exploited. When growth, development, and the physiological basis of yield are understood, it is possible to improve yields of a mungbean crop. Several reports have been made about the contribution of various yield components towards yield (Ahmed *et al.* 1993, Hakim 2008, Mondal *et al.* 2011). To understand the physiological basis of yield difference among the genotypes of mungbean, it is essential to quantify the components of growth, and the variation, if any, may be utilized in crop improvement. Variation in dry matter accumulation and pod production in different genotypes may be related to some factors such as leaf area (LA), crop growth rate (CGR), net assimilation rate (NAR) and relative growth rate (RGR) (Mondal *et al.* 2011).

In view of above facts and the lack of studies on the mungbean in Iraq, this research was conducted to evaluate the influence of varying irrigation frequencies and row spacing on the physiological growth analysis, yield and yield components to determinate the optimum treatments for getting higher seed yield of mungbean (green gram).

MATERIALS AND METHODS

This experiment was conducted during the mungbean (green gram) (*Vigna radiata* (L.) Wilczek), summer growing season, 2012 at the research Field of field crops Department, College of Agriculture, Salahalddin University (Erbil, Iraq). There were two irrigation Intervals every 5 days and every 10 days; three rows spacing (planting density) (20×10, 30×10 and 40×10 cm) using Split Plots arranged in Randomized Complete Block Design. The main plots were irrigation intervals (A): Where irrigating plants every 5 days represent (a_1) and irrigating plants every 10 days (a_2). Factor (B) was represented by three row spacing (planting density) 20×10 (b_1), 30×10 (b_2) and 40×10 cm (b_3)); subsequently, 6 treatment combinations were included in this investigation; each treatment was represented by 3 replicates. Each replicate was included in a plot of 2m length sown with 4 rows. Experiment land was plowed twice vertically and once more horizontally. Irrigation plots were separated from each other's by 4m to avoid water seepage among the main plots of irrigation. Seeds were sown on August 1st 2012, thereafter, germination watering was fulfilled immediately. Weeds were manually eradicated whenever they were observed in the field. In each irrigation time 20 mm of water was applied, and thus treatments of 5 and 10 days irrigation frequencies consumed 560, and 280 mm, respectively.

To study physiological growth characteristics, a total of two harvests were made from one of middle row of each plot were used for sampling. The first crop sampling was done at starting of flowering, while the second crop sampling was done at the starting of pod filling. From each sampling, five plants were randomly selected from each plot and uprooted for collecting necessary parameters. Dry weights were recorded after oven drying at 70 ± 2ºC for 48 hours. The leaf area (cm^2) was calculated by measuring the length breadth of the given leaf (Yoshida, 1972), by leaf area (cm^2) = Kemps constant for dicot leaves (k= 0.66) × length× breadth. The growth analysis was carried out following the formulae of Hunt (1978).

1. $Leaf\ area\ index\ (LAI) = LA/GA$

2.

$$Leaf\ area\ ratio\ (LAR) = LA/W \quad (area/weight)$$

3.

$$Absolute\ growth\ rate\ (AGR) = W_2 - W_1/t_2 - t_1$$

$$(weight/time)$$

4.

$$\text{Re}lative\ growth\ rate\ (RGR) = LnW_2 - LnW_1/t_2 - t_1$$

$$(weight/weight)/time$$

5.

$$Net\ assimilation\ rate\ (NAR) = [W_2 - W_1/t_2 - t_1][Ln_{A_2} - Ln_{A_1}/LA_2 - LA_1]$$

$$(weight/area/time)$$

6. The amount of water applied was used to calculate water use efficiency WUE using the formula suggested by Ehdaie and Waines (1993): WUE = SY / TWU

The symbols used in the above equations are:

LA=leaf area; *GA*=ground area; *W*=total dry weight; *t*=time; TWU = total water used and SY = seed yield.

To study yield and its components, ten plants were harvested on October 5th 2012, and the following trait measurements were calculated: pod number/plant, seeds/pod and plant height (cm) and pod length (cm) were measured by ruler. Biomass yield (g/plant), 1000- seed weight (g), seed weight/plant (g) were weighted and harvest index (%). Twenty plants were harvested

in order to calculate seed yield (g/m^2). Data were analysed using SAS program, version, 9 (2001) for analysis of variance and Duncan Multiple Range Test at $\alpha = 0.05$ probability level was employed for the mean comparisons (Al-Rawi and Khalaf-Allah, 1980).

RESULTS AND DISCUSSION

Leaf area index at starting of flowering (LAI_1) and Leaf area index at starting of pod filling (LAI_2)

Substantial differences were observed among irrigation intervals and row spacing in terms of LAI_1 and LAI_2 (Table 1). The maximum LAI_1 and LAI_2 values were confined to every 5 days irrigation frequency (1.58, 1.69, respectively) and in 20 cm row spacing (1.53, 1.68, respectively). The LAI_1 and LAI_2 in both treatments revealed gradual increases till to attain their peak at the initiation of pod filling. This result is consistent with Mondal *et al.* (2012). Interaction effect between irrigation interval and row spacing was also significant. The highest LAI_1 and LAI_2 was observed in every 5 days irrigation and 20 cm (1.80 and 2.01), respectively which was superior than all other treatment combinations due to the increase in the number of plants per unit area at the narrow spaces between rows at 20 cm row spacing and provide irrigation every 5 days, compared with the wide distances between rows and irrigation every 10 days.

Leaf area ratio at starting of flowering [LAR_1] and Leaf area at starting of pod filling [LAR_2]

Statistical analysis manifested that irrigation intervals had no significant influences on LAR_1 and LAR_2, while varying row spacing had significant effect on the LAR_1 and LAR_2. Maximum LAR_1 and LAR_2 (80.57 and 35.95) were noticed in plots with 20 cm row spacing. Interaction effect between irrigation interval and row spacing was significant. The highest LAR_1 and LAR_2 values were observed in every 5 days irrigation interval and 20 cm (84.70 and 36.44), respectively, which was not differed with that of irrigating every 10 days interval and 30 row spacing (76.44 and 35.45), respectively. It was noted that the low proportion of LAR_2 compared with LAR_2 because the increase in growth of stems and growth of pods which caused a decline in the percentage of leaf area to plant weight.

Absolute growth rate [AGR]

Data presented in Table (1) for AGR reveal that irrigation intervals and row spacing showed significant difference, where the maximum value for AGR (0.48) was recorded in both treatment, irrigation every 5 days and 40 cm spacing. However, crop planted at irrigation every 10 days and 20 cm row spacing produced the minimum AGR of (0.41) and (0.40), respectively. Significantly higher value (0.52) of AGR was recorded at every 5 days irrigation and 40 cm which was superior than all other treatment combinations.

Relative growth rate [RGR]

Varying irrigation intervals had significantly affected the RGR. Maximum RGR (0.06) were noticed in plots irrigated every 5 days. However, lowest RGR (0.04) was recorded in plots irrigated every 10 days. Using different row spacing has significantly affected RGR. Means of row spacing concerning RGR ranged from (0.030) at 20 cm up to (0.065) at 40 cm. This might be due to closer plant intraspaces within rows, resulting in greater competition for light, space and nutrients. These results are in line with Mondal *et al.* (2011). The interaction of irrigation interval and row spacing was significant concerning RGR. The highest value (0.078) was recorded in plots having irrigation every 5 days along with 40 cm row spacing and the lowest value (0.028) was recorded in plots with irrigation every 10 days and 20 cm row spacing.

Net assimilation rate [NAR]

The NAR of a crop represents the net photosynthetic production per unit leaf area duration (Hunt, 1978). There was a significant different between irrigation intervals in NAR. Highest value of NAR (0.65) was recorded in plots irrigated every 5 days, whereas lowest value (0.53) was recorded in plots irrigated every 5 days. Significant variation was observed for NAR among different row spacing. The highest NAR (0.80) was observed at 40 cm row spacing against the lowest NAR (0.36) was recorded at 20 cm row spacing. Interaction effect between irrigation intervals and row spacing was also significant. The highest value of NAR (0.907) was recorded in every 5 days irrigating and 40 cm row spacing, while the lowest value of NAR (0.320) was recorded in every 10 days irrigating and 20 cm row spacing.

Water use efficiency [WUE]

Irrigation intervals differed significantly in WUE. Maximum value for WUE (0.59) was recorded in plots irrigated every 10 days, against, the lowest value (0.50) which was recorded in plots irrigated every 5 days. Means of WUE were also significantly affected by row spacing. Mungbean plants at 20 cm row spacing gave the maximum value (0.65) of WUE, whereas, minimum WUE (0.46) was recorded in crop planted at 40 cm row spacing. The interaction of irrigation intervals and row spacing was significant concerning WUE, and ranged from (0.37) to (0.65). The highest value of WUE (0.65) was recorded in plots irrigated every 5 days and having 20 cm of row spacing. On the other hand lowest value of WUE (0.37) was recorded with the application of treatment having irrigation every 5 days and row spacing of 40 cm (Fig. 1).

Table (1): Mean comparisons of growth, yield and its components of mungbean as affected by irrigation levels and row spacing.

Treatments		LAI_1	LAI_2	LAR_1	LAR_2	AGR	RGR	NAR	WUE
Irrigation interval									
Every 5 day		1.58 a	1.69 a	66.81	32.33	0.48 a	0.06 a	0.65 a	0.50 b
Every 10 day		1.13 b	1.17 b	66.46	31.11	0.41 b	0.04 b	0.53 b	0.59 a
Row spacing									
20 cm		1.53 a	1.68 a	80.57 a	35.95 a	0.40 c	0.030 c	0.36 c	0.65 a
30 cm		1.29 b	1.35 b	63.41 b	32.53 b	0.44 b	0.053 b	0.61 b	0.52 b
40 cm		1.24 b	1.27 b	55.91 c	26.67 c	0.48 a	0.065 a	0.80 a	0.46 c
Irrigation interval × Row spacing									
Every 5 day	20 cm	1.80 a	2.01 a	84.70 a	36.44 a	0.44 bc	0.033 cd	0.401 e	0.65 a
	30 cm	1.49 b	1.56 b	56.23 c	32.19 ab	0.46 b	0.059 ab	0.655 c	0.48 c
	40 cm	1.44 b	1.49 b	59.50 c	28.36 b	0.52 a	0.078 a	0.907 a	0.37d
Every 10 day	20 cm	1.26 c	1.34 c	76.44 ab	35.45 a	0.36 d	0.028 d	0.320 f	0.64 a
	30 cm	1.10 d	1.13 d	70.60 b	32.88 ab	0.42 c	0.046 bcd	0.569 d	0.57 bc
	40 cm	1.03 d	1.06 d	52.33 c	24.99 c	0.44 c	0.052 bc	0.690 b	0.55 bc

LAI_1=Leaf area index at starting of flowering; LAI_2=Leaf area index at starting of pod filling; LAR_1=Leaf area ratio at starting of flowering; LAR_2=Leaf area at starting of pod filling; AGR= Absolute growth rate; RGR=Relative growth rate; NAR=Net assimilation rate; WUE=Water use efficiency.

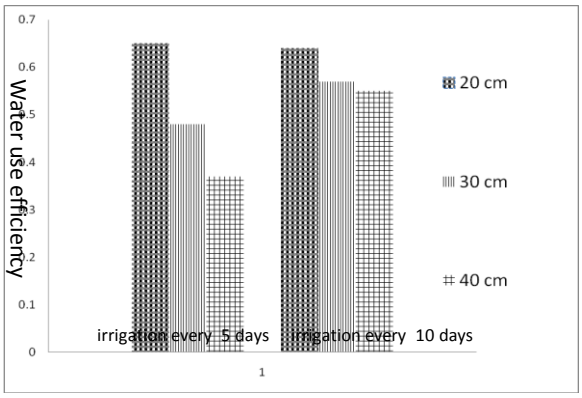

Fig. (1): Water use efficiency of mungbean under different irrigation intervals and row spacing.

Plant height [PH]

Data indicated that PH varied significantly between irrigation intervals. The maximum PH was observed in every 5 days irrigation; Statistical analysis showed that different row spacing had a significant effect on PH. Mean values of the data indicated that the highest PH was recorded at 20 cm (20.50 cm) and 30 cm (19.17 cm) row spacing which was superior than PH at 40 cm row spacing (16.67 cm). Plant height was greater at 20 cm row spacing, because of inter-nodes elongation due to shading affect in an attempt to receive solar energy at upper canopy levels. Similar results were observed by Mansoor *et al.* (2010) whom revealed that the 20 cm row spacing produced the tallest plants. Interaction effect between irrigation interval and row spacing was significant. The highest PH was

observed in every 5 days irrigation and 20 cm (24 cm) and 30 cm (22.67 cm) row spacing which was superior than all other treatment combinations (Table 2).

Pod length [PL]

Table (2) indicated that means of pod length (cm) were significantly affected by irrigation intervals. The lengthiest pods were observed in the every 5 days irrigation with value of 8.63 cm. Means of pod length (cm) were also significantly affected by row spacing and ranged from 7.42 to 8.78 cm and the lengthiest pods (8.78 cm) were recorded in 40 cm row spacing. The shortest pods (7.42 and 7.62 cm) were recorded in 20 and 30 cm row spacing, respectively. The interaction of irrigation intervals and row spacing gave varied values of the detected parameters. Whereas, the lengthiest pods (9.23) were recorded in plots have every 5 days irrigation and 40 cm row spacing. On the other hand shortest pods (6.67 cm) were recorded in the treatment with every 10 days irrigation and 20 cm row spacing. Shortest pods production may be due to relatively higher plant population, which may have resulted in greater competition for light, space and nutrients. These results are also confirmed by Singh and Sahu (1998) and Mansoor *et al.* (2010).

Pod number/plant [PN/plant]

Varying irrigation intervals had significantly affected the PN/plant. Maximum PN/plant (47.78) was noted in plots irrigated every 5 day. Pod number/plant was also affected significantly by different row spacing. Data in Table (2) revealed that the means of row spacing regarding PN/plant ranged from 33.5 to 48.50. The highest number of PN/plant (48.50) was recorded with wider row spacing (40 cm). This can be attributed to greater light interception and increased photosynthetic activity due to the availability of greater space to crop. Lowest PN/plant (33.50) was, recorded in narrow row spacing (20 cm). This might be due to the fact that lower plant number per unit area had utilized nutrients like water, light, CO_2 and N in abundance, which ultimately resulted in the formation of more photosynthesis and number pods/plant. These results are in line with Mehmud *et al.* (1997), Jan *et al.* (2000) and Achakzai, and Panizai (2007). The interaction of irrigation interval and row spacing was also found significant. The combination of irrigation every 5 days and 40 cm row spacing has produced the highest PN/plant (54.00) and the lowest PN/plant (37.00) was recorded in plots with irrigation every 10 days and 30 cm row spacing.

Seed number/pod [SN/pod]

Plants irrigated every five days produced a significant increase in SN/pod as compared to irrigation every 10 days reaching 16.6%. Variation of SN/pod was significant, in relation to other row spacing. The highest SN/pod was obtained in 40 cm row spacing (10.17) against the lowest SN/pod was produced in 20 cm row spacing (7.00). These results are in conformity with Ahamed *et al.* (2011) whom reported that the plants of the treatment 30 × 10 cm spacing produced the highest SN/pod. Interaction effect between irrigation intervals and row spacing was also significant. The highest SN/pod (11.00) was recorded in irrigating every 5 days at 40 cm row spacing.

1000-Seed weight [1000-SW]

Significant variation was observed for 1000-SW among irrigation intervals. The highest 1000-SW (42.95 g) was observed in irrigation every 5 days, against, the lowest 1000-SW (39.22 g) was recorded in irrigation every 10 days. Significant variation was observed for 1000-SW among different row spacing. The highest 1000-SW was obtained in 40 cm row spacing (43.33 g) against the 20 and 30 cm row spacing. Similar results were observed by Kabir and Sarkar (2008). Interaction effect between irrigation intervals and row spacing was also significant. The highest 1000-SW (45.00 g) was observed in irrigating every 5 days at 40 cm row spacing.

Biomass yield/plant [BY/plant]

Irrigation intervals had significantly affected the BY/plant. Maximum BY/plant were noticed in plots irrigated every 5 days (20.21 g) against the lowest BY/plant was produced in plots irrigated every 10 days (15.38 g). BY/plant was also affected significantly by different row spacing. Data in Table (1) revealed that means of row spacing regarding BY/plant ranged from (14.58) to (21.47 g). The highest BY/plant (21.47 g) was recorded with 40 cm row spacing followed with 30 cm (17.33 g) and 20 cm (14.58 g). The interaction of irrigation intervals and row spacing was significantly differed in BY/plant, and ranged from (11.97) to (23.83 g). The highest BY/plant (21.47 g) was recorded in plots having irrigation every 5 days with 20 cm of row spacing. On the other hand lowest BY/plant (14.58 g) was recorded with the application of treatment having irrigation every 10 days and row spacing of 20 cm.

Seed weight/plant [SW/plant]

Variation of SW/plant values was significant when irrigation intervals were compared with each others. The highest SW/plant (7.86 g) was achieved in irrigation every 5 days. SW/plant was significantly affected by row spacing and maximum SW/plant (7.23 g) was recorded in the plots with 40 cm between rows, while the lowest SW/plant (5.43 g) were recorded in the plots with 20 cm row spacing. Interaction effect between irrigation intervals and row spacing was significant in case of SW/plant. The maximum SW/plant (8.31 g) was observed in irrigation every 5 days and 40 cm row spacing which not differed statistically with irrigating every 5 day and 30 cm row spacing (8.00 g) (Fig. 2).

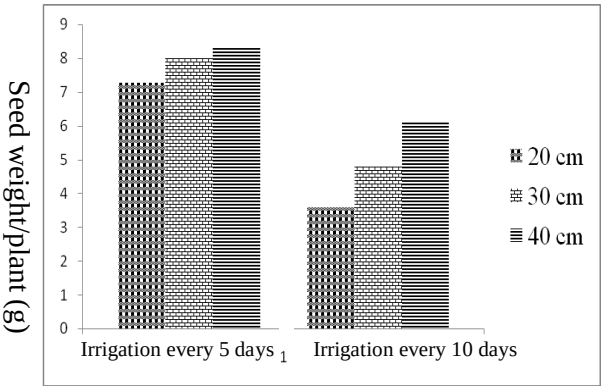

Fig. (2): Seed weight/plant of mungbean under different irrigation intervals and row spacing.

Harvest index [HI]

Analysis of data revealed that irrigation intervals had significant effect on HI. The highest HI was produced in plots irrigated every 5 days (39.33%). Data presented in Table (1) shows that HI was also significantly affected by row spacing. The highest HI was recorded in 30 cm row spacing (36.33%) and not differed with 20 cm row spacing (36.15%), while the lowest value of HI (33.53%) was recorded in 40 cm row spacing. Similar results have been reported by and Sarkar *et al.* (2004) and Ahamed *et al.* (2011). The interaction of irrigation interval and row spacing was also found significant for HI, which ranged from (30.03%), to (42.27%). Maximum harvest index was recorded in plots irrigated every 5 days and 20 cm row spacing. On the other hand the lowest value of HI was recorded in the treatment which irrigated every 10 days with 20, 30 and 40 cm row spacing, respectively.

Seed yield/m^2 [SY/m^2]

The irrigation intervals showed significant differences in their seed yield. The highest SY/m^2 (215.55 g) was produced in plot which was irrigated every 5 days against the lowest SY/m^2 (132.63 g) was recorded in plots irrigated every 10 days. Similar results were reported by Muhammad and Malghani (2000) and Nabizade *et al.* (2011). Variation of SY/m^2 was significant for different row spacing. The highest SY/m^2 (235.91 g) was achieved in 20 cm row spacing, while the lowest SY/m^2 (136.36 g) was produced in 30 cm row spacing. The results are also in accordance with the findings obtained by Achakzai and Panizai (2007). The interaction of irrigation intervals and row spacing was significant for SY/m^2. The maximum SY/m^2 (321.18) was recorded in plots which irrigated every 5 days with 20 cm row spacing, while the lowest SY/m^2 (119.57 g) was recorded in the plots that irrigated every 10 days with 40 cm row spacing (fig. 3).

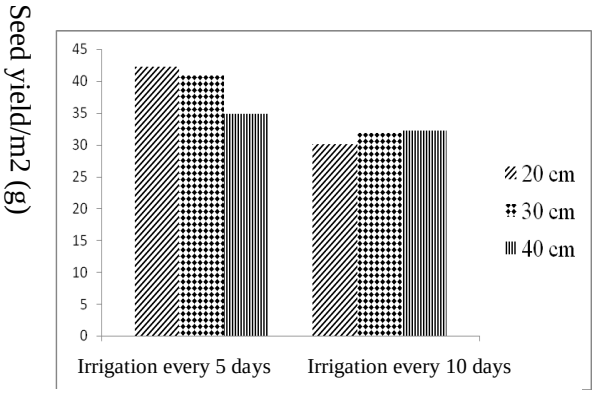

Fig. (3): Seed yield of mungbean under different irrigation intervals and row spacing.

Table (2): Mean comparisons of physiological growth analysis of mungbean as affected by irrigation intervals and row spacing.

Treatments		PH	PL	PN/plant	SN/pod	1000-SW	BY/plant	SW/plant	HI	SY/m^2
Irrigation interval										
Every 5 day		21.67 a	8.63 a	47.78 a	9.33 a	42.95 a	20.21 a	7.86 a	39.33 a	215.55 a
Every 10 day		15.89 b	7.28 b	35.00 b	8.00 b	39.22 b	15.38 b	4.84 b	31.34 b	132.63 b
Row spacing										
20 cm		20.50 a	7.42 b	33.50 c	7.00 c	39.09 b	14.58 c	5.43 c	36.15 a	235.91 a
30 cm		19.17 a	7.67 b	42.17 b	8.83 b	40.83 b	17.33 b	6.39 b	36.33 a	136.36 c
40 cm		16.67 b	8.78 a	48.50 a	10.17 a	43.33 a	21.47 a	7.23 a	33.53 b	150.01 b
Irrigation interval × Row spacing										
Every 5 day	20 cm	24.00a	8.17 a	42.00 bc	7.66bc	41.19 b	17.20 b	7.28 ab	42.27 a	321.18 a
	30 cm	22.67 a	8.50 a	47.33 b	9.33 a	42.67 ab	19.60 b	8.00 a	40.84 ab	145.01 c
	40 cm	18.33 b	9.23 a	54.00 a	11.00 a	45.00 a	23.83 a	8.31 a	34.88 bc	180.45 b
Every 10 day	20 cm	17.00 b	6.67 b	25.00 d	6.33 c	37.00 c	11.97 d	3.59 d	30.03 c	150.63 c
	30 cm	15.67 b	6.83 b	37.00 c	8.33 b	39.00 bc	15.07 c	4.78 c	31.82 c	127.70 d
	40 cm	15.00 b	8.33 a	43.00 bc	9.33 a	41.67 b	19.10 b	6.14 b	32.17 c	119.57 d

Means with the different letter in each column and treatment are significantly different according to Duncan Multiple Rang Test at 5% probability level.
PH=Plant height; PL=Pod length; PN/plant=Pod no./plant; SN/pod=Seed no./pod; 1000-SW=1000-seed weight; BY/plant=Biomass yield/plant; SW/plant=Seed weight/plant; HI= Harvest index; SY/m^2=Seed yield/m^2.

It can be concluded that most of the physiological growth measurements, yield and yield attributes showed superior value at irrigation every 5 days interval and 20 × 10 cm row spacing due to abundant of available moisture and wider space allows individual plants to produce high values of these characters due to fewer plants per unit area. The highest seed yield/m^2 noted with 20 × 10 cm might be due to large number of plants per unit area which compensated the effects of decrease in other yield components like seed weight/plant, pod number/plant, seed number/pod ….etc. with. These components though decreased on per se basis, yet yield actually increased on per unit area basis. The plants grown with wider spacing had more area of land around them to draw the nutrition and had more solar radiation to absorb for better photosynthetic process and hence perform better at an individual basis (Ahamed *et al.,* 2011). This study, therefore, reveals that irrigation every 5 days with 20 row spacing would be the optimum treatment combination for maximum yield of mungbean under summer conditions of northern Iraq.

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چەند ڤەکولینێن فیسیۆلۆجی لسەر شرۆڤەکرنا گەشە و بەرهەم و پێکهاتێن ماشێ لژێر دەمێن ئاڤدانێ ودووڕێن چاندنێ

بوختە

ئەڤ لێکۆلینە لە وێستگەیێ تاقیکرنێن چاندنێ ل زانکویا سەلاحەددینێ/ هەڤلێر لە دەمێ هاڤینا 2012 ژبو لێکۆلینێن لسەر کارتێکرنا دوو دەمێن ئاڤدانێ (هەر 5 ڕۆژ و هەر 10 ڕۆژ) و سێ دووڕێین چاندنێ (10 ×20 و 10×30 و 10× 40 سم) لسەر شروڤەکرنا گەشا فیسیۆلۆجی وەک رێنیشاندەر ڕووبەرێ پەلکا و ڕێژا ڕووبەرێ پەلکا و تێکرا گەشا ڕێژەیی و (صافی التمپیل الچویی) و بەرهەم و پێکهاتە و شیانا ماشێ و بکاربرنا ئاڤێ. سیستەمێ (القگع المنشقه فی تصمیم القگاعات العشوائیه الکامله) هاتە بکارئینان ب سێ مکررا. پێوەرێن گەشا فیسیۆلۆجی و بەرهەم و پێکهاتێن وێ ژلایێ مەعنەویڤە جودا بوون ب جوداهیا دەم و دووڕێن ئاڤدانێ ل ناڤبەرا هێلا و ب هەڤڕا ژی.بلندترین بهایێت ڤان سیفاتا ب دەستڤەهاتن لە دەمێ ئاڤدانێ لە هەر پێنج ڕۆژان.ڕووەکێن چاندی ل دووڕێین10×40 سم بلندترین بهایێن ڤان سیفاتان ژی دانێ ل دەمێ ب هەڤڕا ژی لە دەمێن ئاڤدانێ و دووڕێین چاندنێ، ئاڤدان ڕووەکی ل هەر 5 ڕۆژا دگەهل دووڕیا 10×40 سم، ل زۆر سیفاتا بلندترین بها هەبین ل ڕووەکێن تەکی. لێ ل دەمێ ئاڤدانا 5 ڕۆژ و و دووڕیا 10×20 سم بلندترین بەرهەمی توڤی بۆ ئێکا ڕووبەرووی (321.18 گم/م2) هەبوو، ژبلی شیانا بکاربرنا ئاڤێ کو دشێت شیرەت بێتە کرن بوپشت گرێدان ب ڤی گونجانی ل ناڤبەرا هەردوو هوکارا بۆ بەرهەم ئینانا بلندترین بەرهەمێ توڤێ ماشێ ل بن کاودانێن ژینگەهیی ل وەرزێ هاڤینێ ل هەڤلێرێ.

دراسات فسيولوجية على تحليل النمو والحاصل ومكوناته للماش تحت فترات الري ومسافات الزراعة

الخلاصة

أجريت هذه الدراسة في محطة التجارب الزراعية في جامعة صلاح الدين/أربيل خلال صيف 2012 من أجل دراسة تأثير فترتي الري (كل 5 أيام وكل عشرة أيام) وثلاث مسافات زراعية (10 × 20 و 10 × 30 و 10 × 40 سم) على تحليل النمو الفسيولوجي مثل دليل المساحة الورقية ونسبة المساحة الورقية ومعدل النمو النسبي وصافي التمثيل الضوئي والحاصل ومكوناته وكفاءة استهلاك الماء للماش.تم استخدام نظام القطع المنشقة في تصميم القطاعات العشوائية الكاملة بثلاثة مكررات. أختلفت قياسات النمو الفسيولوجية والحاصل ومكوناته معنوياً باختلاف فترات الري والمسافات بين السطور والتداخل بينهما. تم الحصول على أعلى القيم لهذه الصفات عند الري على فترة كل 5 أيام . أعطت النباتات المزروعة على مسافة 10 × 40 سم أعلى القيم لهذه الصفات أيضاً. في حالة التداخل بين فترات الري ومسافات الزراعة فان تداخل فترة الري كل 5 أيام والمسافة 10 × 40 سم أعطت أعلى القيم في معظم الصفات على أساس النبات الفردي، بينما أعطى تداخل فترة الري 5 أيام والمسافة 10 × 20 سم أعلى حاصل بذور لوحدة المساحة (321.18 غم/م^2) بالاضافة الى كفاءة استهلاك الماء والذي يمكن التوصية باعتماد هذا التوافق بين العاملين لانتاج أعلى حاصل بذور للماش تحت الظروف البيئية لموسم الصيف في أربيل.

PERFORMANCE AND VARIANCES FOR BREAD WHEAT GENOTYPES UNDER DIFFERENT LEVELS OF SEEDING RATES

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ABSTRACT

The effect of seed rates (100, 120 and 140 kg/ha) on grain yield and some of its components, (number of grains per spike, 1000-grain weight), plant height number of days to the flowering and leaf area of 16 introduced bread wheat genotypes along with local one (Azady) was investigated at the agronomic research station of Faculty of Agriculture and Forestry, Duhok University, during 2011-2012 season, and the 16 genotypes excluding local one were evaluated during the two seasons (2010-2011 and 2011-2012) under seed rate of 140 kg/ha, using randomized complete block design with three replications. The effect of seed rates, seasons and genotypes was significant for all characters except 1000-grain weight in case of seed rate. Genotype x seed rate and genotype x season interactions were highly significant for all characters except number of days to flowering for genotype x seed rate. Plant height, number of day to flowering, 1000-grain weight and grain yield were high at higher seed rate of 140 kg/ha, while number of grains per spike and leaf area were high at lower seed rate of 100 kg ha. Among wheat genotypes, SETTAT-85, SALE-7 and KHEMISSET-1 produce higher plant height and grain yield/ha, SETTAT-85 surpassed others for number of days to flowering and JAWAHIR-13 and KHEMISSET-1 produce maximum 1000-grain weight. In interaction, maximum grain yield 5.647 ton/ha was produced by SETTAT-85 with seed rate of 140 kg/ha, and 8.194 ton/ha was produced by KHEMISSET-1 in 2010-2011 season. Broad sense heritability was high for plant height and moderate for number of days to flowering, and low for other characters.

KEY WORDS: breed wheat genotype seed rates.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most widely cultivated crop among the cereals and main food for people all over the world (Rauf et al., 2007). It is the leading grain crop of the temperate climates of the world, and is grown on 215.27 million hectares in the world (FAO, 1999). Nowadays, increase wheat production due to encountering more demand as a consequence of population growth in many countries is still a challenge (Hamam et al., 2008). Wheat ranks first in the world cereal production and is a staple food of about one third of the world's population (Hussain et al., 2010).

To feed the ever-increasing population in any country, the need for more wheat will be continued. There are high possibilities to increase wheat yield through developing new high yielding varieties and by adoption of proper package of technology (Arian *et al*. 2002; Mahboob *et al*. 2005). Concerns are being expressed that yield plateau have been reached in major crop species including wheat. If further increases in food production per hectare are to be realized, improved management systems and cultivars, which respond to cultural practices, must be developed. The continuous supply of new germplasm material as donor of various genes of agronomic importance is a vital prerequisite for further improvement of wheat cultivars (Masood *et al*. 2005).

Plant density is one of the major factors determining the ability of the crop to capture resources; it is of particular importance that it is being under fairly close control by the farmers in most wheat-producing systems. There has been interest in defining the relationships between density and crop yield quantitatively in order to establish optimum populations and maximum attainable yields under various situations. As a result, the effect of density on crop productivity has received attention (Harper, 1977). There is no uniform recommendation by agronomists regarding the seed rate for unit area, for example, Ciha (1993) reported that higher yield can be obtained by sowing 75 kg seed ha-1. While Singh and Singh (1984), Khan (1993) and Shah (1994) recommended that 100 kg seed rate ha-1 gave higher grain yield of wheat.

In addition, of environmental of influences on phenotypic performance of a genotype. The

detection of significant GE interaction indicates that phenotypic responses to environmental changes are not same for all genotypes. This may mean that the best genotype in one environment is not the best in another. While statistical significance of the interaction is important in estimating various genetic and environmental parameters, it is the size of the interaction components relative to those of the genetic components that directs breeders as to the most likely area of adaptation of a cultivar. If the interaction components are large relative to the genotypic components, and if they are related to predictable environmental factors (such as geographic areas, major pest problems, or soil differences), the breeder searches for a cultivar to meet the specific requirements of that environment. If the interaction is small and unpredictable (such as microclimatic or yearly variations in weather, management practices and some pest problems), the breeder searches for a cultivar that has general adaptabilit and universal performance over the range of environments.

The objectives of this study were to evaluate : (1) the performance of several introduced bread wheat genotypes under different seeding rates, (2) to evaluate the genotypes for two growing seasons and (3) to estimate variance components and broad sense heritability for the studied characters.

MATERIALS AND METHODS

The field experiment was laid out at the agronomic research station of Faculty of Agriculture and Forestry, Duhok University during 2010-2011 and 2011-2012 seasons. The Randomized complete block design with three replications was used. Sixteen introduced bread wheat genotypes (2 to 17) ICARRDA (Table 1) in addition to the local variety Azady (1) were tested during 2011-2012 seasons, under seeding rates of 100, 120 and 140 kg/ha for each genotype, and the

Table (1): Pedigree of bread genotypes used in the study

No.	Name	Plot-Var	Pedigree
1	Azady		(local)
2	BABAGA-3	516-516	ICW93-0065-2AP-0L-2AP-0L-0AP
3	NS732/HER//ARRIHANE/3/REGRAG-1	514-514	ICW00-0894-1AP-0AP-0AP-19AP/MOR-0AP/MOR-0AP
4	QAFZAH-31	562-501	CMSS9Y00621S-4AP-3AP-4AP-0APS-0AP
5	SHIBILL-2	512-512	ICW99-0451-17AP-0AP-0AP-41AP-0AP
6	SETTAT-85	525-521	ICW01-21116-4AP-4AP-0AP-0AP-12AP-0AP
7	SALE-7	519-519	ICW01-00135-0AP-1AP-0AP-0AP-8AP-0AP
8	MORSUD-32	520-520	ICW01-00162-0AP-8AP-0AP-0AP-2AP/MOR-0AP/MOR-0AP
9	JAWAHIR-13	557-505	ICW97-0410-4AP-0APS-0AP-3AP-9AP-3AP-0AP
10	SDRAA-1	563-513	ICW00-0629-1AP-0AP-0AP-16AP-0AP
11	JUMMANA-5	522-522	ICW01-21125-2AP-7AP-0AP/0TS-0AP-5AP-0AP
12	ABU-REYAA-1	507-507	ICW97-0686-0APS-1PS-0APS-050AP-0APS-27AP-0AP
13	ALFAJER-1	547-504	CMSS98Y04676S-040Y-0B-0MXI-0AP-0AP-18AP-0AP
14	NS732/HER//ARRIHANE/3/REGRAG-1	555-515	ICW00-0894-1AP-0AP-0AP-23AP/MOR-0AP/MOR-0AP
15	SETTAT-85	521-521	ICW01-21116-4AP-4AP-0AP-0AP-2AP-0AP
16	SALE-7	559-519	ICW01-00135-0AP-1AP-0AP-0AP-16AP-0AP
17	KHEMISSET-1	523-523	ICW01-21214-1AP-2AP-0AP-0AP-4AP/MOR-0AP/MOR-0AP

sixteenth genotypes excluding local one were evaluated during the two seasons with seeding rate 140 kg/ha.

Each plot contained two rows 2.5 meter a long and 15 cm apart. The field was irrigated after planting date (20 December and 22 November for seasons 2010-2011 and 2011-2012 respectively) by sprinkler for about six hours only and then entirely depended upon natural precipitation (the amount of rain for the months December/2010, January, February, March, April and May/2011 were 62.4, 80.5,

55.0, 20.0, 138.3 and 27.2mm, and for the months October, November, December/2011, January, February, March, April, May and June were 7.5, 25.4, 26.6, 78.8, 46.5, 63.9, 16.6, 0.0 and 0.5 respectively). Fertilizers were applied at the rate of 400 kg/ha of NPK (18:23:0) before planting, and N as urea at the rate of 200 kg/ha, after a month of planting, and herbicide (pallas) used to control narrow and broad leaves weeds at the rate of 450-500 ml/ha at the stage of 3–4 leaves. The following characters were measured: plant height in cm (PH), number of days to flowering (NDF), number of grains per spike (NGS), 1000-grain weight in gm (1000 GW), leaf area (LA) and grain yield in ton/hectare (GY).

Analysis of variance was carried out according to the method of used design, and differences between means were tested according to duncan's multiple range test (Gomez and Gomez, 1983). Depending on expected mean square from analysis of variance for each characters, environmental variance (σ^2E), genotypic variance (σ^2G), phenotypic variance (σ^2P) and broad sense heritability were estimated (Singh and Chaudhary, 2007). (less than 40% is low, 40-60% is moderate, more than 60% is height) All statistical and genetical analysis were performed by using SAS (Statistical Analysis System V. 9) and Microsoft Office Excel 2003.

RESULTS AND DISCUSSION

(1) performance of the genotypes under different seeding rates:

Table 2. showed that mean square of seed rate was significant at 1% level for PH, NGS, NSPS, LA and GY and at 5% level for NDF and non significant for 100 GW, while that of genotypes and its interaction with seed rate was highly significant for all studied characters except NDF in case of genotype x seed rate interaction which was not significant, Nauman *et al.* (2011) found that different seed rates affected significantly the various characters under study especially ,plant height, spike length, 1000-grain weight and economical yield**.**

Table (2): Analysis of variance of seed rate and genotypes for studied characters.

Source	*df*	*Mean square*					
		PH (cm)	NDF	NGS	1000 GW(gm)	LA	GY Ton/h
Reps.	2	33.144	3.614	5.175	15.596	7.238	0.047
Seed rate (S)	2	437.93**	12.67*	6.918**	1.026	42.21**	0.834**
Genotype (G)	16	459.03**	152.16**	173.71**	70.06**	271.69**	3.299**
G x S	32	5.935**	6.222	59.85**	45.76**	131.03**	2.183**
Error	100	0.591	3.241	0.662	0.545	1.771	0.005
CV%		1.012	1.193	2.251	2.969	4.281	2.284
		Variance components					
σ^2G		50.938	16.215	19.228	7.724	29.991	0.366
σ^2SG		1.781	0.994	19.729	15.072	43.086	0.726
σ^2P		53.31	20.45	39.619	23.341	74.848	1.097
Heritability		95.551	79.291	48.532	33.092	40.069	33.364

(**) and **(*)** significant at 1% and 5% level respectively.

Means of seeding rates for studied characters as average of genotypes presented in Table 2., it was shown that maximum PH, NDF, 1000GW and GY per hectare produced by higher seeding rate of 140 kg/ha (79 cm, 151.33 day, 24.973 gm and 3.107 ton respectively), while maximum NGS and LA were recorded by lower seeding rate of 100 kg/ha (36.555 and 32.105 respectively). In a study conducted by Da'bosh (2006) found that increase the rate of seed led to short period from planting until the completion of flowering, while plants tended to mature early, about six days, an increase in PH, number tillers, number of spikes/$m^2$and GY by 15.1%,

Table (3): Means of seed rates for studied characters as average of genotypes under different seed rates.

Seed rate	*Characters*					
	PH (cm)	NDF	NGS	1000 GW(gm)	LA	GY Ton/h
100 kg/h	73.157 c	150.35 b	36.555 a	24.692 a	32.105 a	2.860 c
120 kg/h	75.686 b	151.00ab	35.978 b	24.869 a	30.767 b	3.042 b
140 kg/h	79.000 a	151.33 a	35.870 b	24.973 a	30.368 b	3.107 a
Mean	75.948	150.895	36.134	24.845	31.080	3.003

- Means followed by the same letters for each character have no significant difference.

NGS and 1000GW. The data presented in Table 4 revealed that significant differences were found between genotypes as average of seeding rates in all characters. Maximum counts were found in genotypes (15) SETTAT-85, (16) SALE-7 and (17) KHEMISSET-1 for PH and 4 and 14 for NDF genotypes(10) SDRAA-1, (17) KHEMISSET-1 and (4) QAFZAH-31 for NGS, 1000GW and LA, respectively, and genotypes (15) SETTAT-85 and (16) SALE-7 for GY/ha.

Table (4): Means of genotypes for studied characters as average of seed rates**.**

Genotypes	*Characters*					
	PH (cm)	NDF	NGS	1000 GW(gm)	LA	GY Ton/h
1	71.556 i	152.33 b	30.793 k	20.350 g	27.736 g	1.660 j
2	71.889 i	152.44 b	40.452 c	25.570 d	26.064 h	3.368 c
3	67.222 k	153.22 b	32.847 ij	28.188 b	23.231 i	3.288 d
4	73.111 h	152.67 b	41.803 b	27.753 b	39.753 a	3.345 cd
5	68.778 j	155.44 a	33.499 hi	23.677 e	26.101 h	2.473 h
6	81.667 c	141.00 f	35.586 fg	25.433 d	26.048 h	3.389 bc
7	82.889 b	150.33cd	36.566 e	23.721 e	36.887bc	2.316 i
8	73.889 g	147.67 e	35.558 fg	25.751 d	30.423 f	2.992 f
9	72.778 h	152.11bc	32.669 j	27.773 b	32.189 e	2.296 i
10	68.667 j	153.11 b	48.147 a	20.814 fg	38.158 b	2.882 g
11	77.333 f	153.33 b	39.892 c	24.037 e	21.982 j	2.862 g
12	63.889 l	152.00bc	37.419 d	20.752 fg	31.272ef	2.418 h
13	79.778 d	153.00 b	31.463 k	21.121 f	27.943 g	3.124 e
14	78.444 e	153.89ab	32.871 ij	26.843 c	35.781cd	3.455 b
15	86.222 a	141.00 f	34.980 g	26.491 c	34.708 d	3.904 a
16	86.444 a	152.11bc	35.838 ef	25.049 d	32.312 e	3.870 a
17	86.556 a	149.56 d	33.903 h	29.034 a	37.774 b	3.410 bc
mean	75.948	150.895	36.134	24.845	31.080	3.003

- Means followed by the same letters for each character have no significant difference.

Lower number of days from planting to flowering of 141 days recorded by genotypes (6) SETTAT-85 and (15) SETTAT-85. The maximum counts surpassed the local variety (Azady) for PH, NGS, 1000GW, LA and GY by percents 20.96, 56.36, 42.67, 43.33 and 135.8% respectively, and the genotypes (6) SETTAT-85 and (15) SETTAT-85 were 8.04% more earlier in flowering than local variety Azady. The means of genotypes x seed rates combinations presented in Table 5. Its results revealed the presence of significant differences for all characters. The maximum values of PH (89 cm), 1000GW (34.58 gm) and grain yield (5.647 ton/ha) recorded by genotypes (17) KHEMISSET-1, (4) QAFZAH-31 and (15) SETTAT-85 with seeding rate 120 and 140 kg/ha respectively. For NGS and LA, the maximum values recorded by genotypes (10) SDRAA-1 with lower seeding rate and (14) NS732/HER //ARRIHANE- /3/REGRAG-1 with seeding rate of 120 kg/ha respectively, while the least number of days to flowering (141 day) recorded by genotypes (6) SETTAT-85 with seeding rate of 100 kg/ha and (15) SETTAT-85 with seeding rates of 100, 120 and 140 kg/ha.

Table (5): Means of combination between genotypes and seed rate for studied characters.

Seed rate x Genotypes		*Characters*					
		PH (cm)	NDF	NGS	1000 GW(gm)	LA	GY Ton/h
100 kg/h	1	69.00 r	152.33a-f	31.63tuv	23.37o-s	26.42qrs	1.957u
	2	67.33st	152.67a-e	36.71h-l	26.70gh	31.33lmn	2.713p
	3	63.00 v	155.33ab	33.25p-s	29.77cd	23.91tuv	3.015n
	4	69.00 r	152.67a-e	33.38p-s	26.15g-j	30.21mno	1.610w
	5	64.33 u	155.33ab	34.52m-p	25.87g-k	21.59vwx	2.313 s
	6	78.33hi	141.00i	36.33i-l	29.12de	27.7opq	3.729gh
	7	80.33 g	149.0fgh	42.37 d	25.48h-l	38.27ef	1.827v
	8	70.67 q	148.0gh	37.61ghi	25.47h-l	35.21g-j	2.375 s
	9	69.00 r	151.0c-g	34.34n-q	26.54ghi	36.99efg	2.857o
	10	65.00 u	152.33a-f	52.20 a	20.53vw	38.17ef	3.012n
	11	75.67kl	152.33a-f	41.82de	25.19i-m	29.33nop	2.969no
	12	61.33 w	149.33e-h	38.03fgh	20.85uvw	37.89ef	3.061n
	13	77.33ij	149.0fgh	31.98stu	19.62wxy	32.29klm	2.603pqr
	14	75.00lm	153.0a-d	39.21 f	24.01m-q	31.34lmn	3.442jkl
	15	86.00 c	141.00i	28.07 y	23.32o-s	35.24g-j	4.191d
	16	87.33 b	151.67b-f	35.48k-n	21.21tuv	30.45mno	2.997n
	17	85.00cd	150.0c-h	34.51m-p	26.58gh	39.43de	3.951ef
120 kg/h	1	71.33 q	152.33a-f	35.37lmn	18.77 y	28.18opq	1.372x
	2	72.00pq	151.67b-f	46.29 c	26.95fg	22.64uvw	3.549ij
	3	67.67rs	152.67a-e	36.26i-l	33.42 a	21.31wx	4.005 e
	4	74.00mno	153.0a-d	50.31 b	34.58 a	39.32de	5.411 b
	5	68.00rs	155.67a	29.62wx	24.59k-o	30.18mno	2.149 t
	6	82.33 f	141.00 i	36.97g-k	25.17i-m	27.05pqr	3.357lm
	7	83.33ef	149.0fgh	30.33vw	24.43l-o	31.64lmn	2.576rq
	8	73.0nop	147.0 h	33.71pqr	20.44vw	22.96t-w	3.754 g
	9	73.0nop	152.33a-f	32.4r-u	22.84qrs	36.06fgh	2.155 t
	10	68.33rs	152.0a-f	42.79 d	20.57vw	34.15h-k	2.672pq
	11	77.0ijk	152.67a-e	35.68j-n	24.9j-n	18.98yz	3.415kl
	12	64.00uv	154.67ab	37.08g-j	21.22tuv	19.99xy	2.493 r
	13	79.33gh	155.33ab	33.83o-r	20.05v-y	29.13nop	3.252m
	14	78.33hi	155.33ab	26.6 z	28.52de	50.80a	3.377 l
	15	84.67cde	141.00 i	36.03j-m	24.26l-p	33.51i-l	1.875uv
	16	84.67cde	151.67b-f	35.32l-o	22.99p-s	31.29lmn	3.626hi
	17	85.67cd	149.67d-h	33.03p-t	29.08de	45.85b	2.681pq
140 kg/h	1	74.33mn	152.33a-f	25.37 z	18.92xy	28.6opq	1.651w
	2	76.33jkl	153.0a-d	38.35fg	23.06p-s	24.23stu	3.843fg
	3	71.00 q	151.67b-f	29.04wxy	21.38tuv	24.48stu	2.845 o
	4	76.33jkl	152.33a-f	41.72de	22.53rst	49.73a	3.014 n
	5	74.0mno	155.33ab	36.36i-l	20.57vw	26.53qrs	2.956no
	6	84.33de	141.00 i	33.46p-s	22.02stu	23.39t-w	3.079 n
	7	85.00cd	153.0a-d	37.0g-k	21.25tuv	40.75cd	2.545 r
	8	78.00ij	148.0gh	35.35lmn	31.35 b	33.1jkl	2.847 o
	9	76.33jkl	153.0a-d	31.26uv	33.94 a	23.52t-w	1.875uv
	10	72.67op	155.00ab	49.45 b	21.34tuv	42.15c	2.961no
	11	79.33gh	155.0ab	42.18de	22.02stu	17.63z	2.201 t
	12	66.33 t	152.0a-f	37.15g-j	20.19vwx	35.93f-i	1.700 w
	13	82.67 f	154.67ab	28.58xy	23.69n-r	22.42uvw	3.517ijk
	14	82.00 f	153.33abc	32.81q-t	28.0ef	25.2rst	3.547ij
	15	88.00ab	141.00 i	40.83 e	31.89 b	35.38g-j	5.647 a
	16	87.33 b	153.0a-d	36.72h-l	30.94bc	35.19g-j	4.988 c
	17	89.00 a	149.0fgh	34.16n-q	31.44 b	28.040pq	3.598 i
mean		75.948	150.895	36.134	24.845	31.080	3.003

- Means followed by the same letter for each character have no significant difference.

(2) performance of the genotypes under different environments:

Combined analysis of variance of genotypes for the two planting seasons 2010-2011 and 2011-2012 was presented in Table 6. The mean square of seasons and genotypes was highly significant for all studied characters indicating the presence of significant differences among seasons and genotypes means for these characters, Al-Otayk (2010) reported that combined analysis of variance showed that PH, NGS, and GY were significantly influenced by years and genotypes. The genotypes x seasons interaction mean square was also highly significant for all characters, indicating the presence of genotype x environment interaction, which revealed that the performance of some genotypes was different with environmental variation. Mohammed (2009) reported from his study that mean square was significantly different among the genotypes, the environments and their interaction for grain yield and its components. Values of broad sense heritability were high for NDF and moderate for PH and NGS and low for other characters It is evident from the date presented in Table 7 that differences between means of the two seasons (as average of genotypes) were significant for all characters. Least NDF, higher 1000GW and GY was recorded in season 2010-2011, while higher values of PH, NGS and LA was noted in season 2011-2012, These differences may be caused by different amounts and distribution of rainfall between the two seasons.

The data regarding genotypes means (as average of the two seasons) presented in Table 8. It reveals that there were significant differences for all characters among the sixteen wheat genotypes. Among these genotypes, a visible dominant of (15) SETTAT-85 was found over most other genotypes for PH and GY. For NGS and LA the genotype (4) QAFZAH-31 significantly surpassed others, while for 1000GW, the genotype (9) JAWAHIR-13, ranks the first followed by genotype (17) KHEMISSET-1. These differences between the genotypes

Table (6): *Analysis of variance of genotypes in the two seasons for studied characters.*

Source	df	PH (cm)	NDF	NGS	1000 GW(gm)	LA	GY Ton/h
Season (S)	1	2242.7**	34277.1**	1888.2**	12906.2**	12461.6**	123.44**
Reps/season	4	7.229	0.833	1.007	2.961	0.282	0.008
Genotypes (G)	15	301.46**	90.989**	125.85**	63.146**	126.36**	3.273**
G x S	15	99.689**	24.975**	69.55**	46.086**	114.11**	3.581**
Error	60	6.518	0.711	0.558	0.719	0.108	0.009
CV%		3.429	0.637	2.328	2.297	1.723	2.131
				Variance components			
σ^2G		49.157	15.046	20.882	10.405	21.042	0.544
σ^2SG		31.057	8.088	22.997	15.122	38.001	1.191
σ^2P		86.732	23.845	44.437	26.246	59.151	1.744
Heritability		56.677	63.099	46.992	39.644	35.573	31.193

(**) significant at 1%.

Table (7): Means of the two seasons for studied characters as average of genotypes.

Season	*Characters*					
	PH (cm)	NDF	NGS	1000 GW(gm)	LA	GY Ton/h
2010/2011	69 625 b	113.479 b	27.656 b	48.541 a	7.692 b	5.466 a
2011/2012	79.292 a	151.271 a	36.526 a	25.351 b	30.479 a	3.198 b
mean	74.458	132.375	32.091	36.946	19.086	4.332

Table (8): Means of genotypes for studied characters as average of the two seasons.

genotypes	*Characters*					
	PH (cm)	NDF	NGS	1000 GW(gm)	LA	GY Ton/h
2	63.833 h	132.667 e	31.130 g	35.648 g	15.220 i	3.795 h
3	78.000cd	133.833 d	27.562 j	38.332 de	16.313 h	3.902 g
4	68.333 g	134.333cd	39.378 a	36.748 f	27.917 a	4.252 e
5	73.667ef	135.667ab	29.532 h	32.537 j	17.080 g	3.519 i
6	77.500cd	125.667 g	30.060 h	34.743 gh	16.560 h	4.083 f
7	80.500bc	134.333cd	36.332 c	34.198 hi	24.548 c	4.097 f
8	73.833ef	128.333 f	31.937 g	37.633 ef	20.583 e	4.441 d
9	69.167 f	135.333bc	26.962 j	42.510 a	15.572 i	3.779 h
10	67.500 g	136.667 a	37.353 b	33.917 hi	27.067 b	3.528 i
11	72.167 f	136.667 a	36.918 bc	35.573 g	10.852 j	4.234 e
12	60.833 i	132.000 e	33.960 e	34.062 hi	20.793 e	4.027 f
13	78.833cd	135.167bc	21.910 k	33.178 ij	15.242 i	3.917 g
14	76.167de	135.000bc	35.388 d	39.725 c	17.308 g	4.808 c
15	84.000 a	124.667 h	32.882 f	38.872 cd	21.435 d	5.838 a
16	83.500ab	128.333 f	33.663 ef	41.413 b	20.440 e	5.193 b
17	83.500ab	129.333 f	28.490 i	42.043 ab	18.420 f	5.896 a
mean	74.458	132.375	32.091	36.946	19.086	4.332

- Means followed by the same letters for each character have no significant difference.

for these characters may explained by the differences in their genetic factors. The above results were obtained for genotypes could be used in crop breeding programs by hybridization. Table 9 shows means of combinations between genotypes and growing seasons for all characters. In general it is clear that all genotypes in 2010-2011 season was characterized as the most earliest in flowering, and its plants were also less height and gave less number of grains per spike and 1000-grain weight and the highest grain yield per hectare as compared to 2011-2012 season, except the genotypes (2) BABAGA-3 and (5) SHIBILL-2, Where their performance was consistent in both seasons for PH and GY respectively. It was shown that genotype (17) KHEMISSET-1 in the 2nd season gave higher PH of 89 cm, with no significant difference from genotypes (15) SETTAT-85, (16) SALE-7, (6) SETTAT-85 (7) SALE-7 in the 2nd season and (3) NS732/HER//ARRIHANE/3/ REGRAG-1 in the 1st season. For NDF, genotype (16) SALE-7 in the 1st season was significantly more earliest flowering compared to other genotypes in both

Table (9): Means of combination between genotypes and seasons for studied characters.

Season x Genotypes		*Characters*					
		PH (cm)	NDF	NGS	1000 GW(gm)	LA	GY Ton/h
2010/2011	2	51.333 n	112.33 j	23.910 qr	48.237 de	6.213 t	3.746 jk
	3	85.00 ab	116.00 i	26.087 op	55.283 a	8.150 qr	4.959 g
	4	60.333 m	116.33 hi	37.037def	50.970 c	6.103 t	5.491 ef
	5	73.333g-j	116.00 i	22.700 r	44.500 hi	7.627 rs	4.081 i
	6	70.67ijk	110.33 k	26.663 o	47.470 ef	9.727 o	5.086 g
	7	76.00e-h	115.67 i	35.663 gh	47.150 efg	8.350 pq	5.648 de
	8	69.667jk	108.67 l	28.520 n	43.917 ij	8.067qrs	6.034 c
	9	62.00 lm	117.67 gh	22.660 r	51.080 c	7.627 rs	5.683 d
	10	62 33 lm	118.33 g	25.260 p	46.490 fg	12.023 n	4.094 i
	11	65.000 l	118.33 g	31.660 lm	49.127 d	4.070 u	6.267 b
	12	55.333 n	112.00 j	30.770 m	47.933 def	5.653 t	6.353 b

	13	75.00f-i	115.67 i	15.240 s	42.660 j	8.067qrs	4.317 h
	14	70.33ijk	116.67 hi	37.970de	51.450 bc	9.417 o	6.069 c
	15	80.00cde	108.33 l	24.930 pq	45.850 gh	7.493 s	6.029 c
	16	79.67def	103.67 m	30.610 m	51.883 bc	5.687 t	5.397 f
	17	78.00d-g	109.67 kl	22.817 r	52.650 b	8.803 p	8.194 a
2011/2012	2	76.33e-h	153.00cd	38.350 d	23.060 no	24.227 j	3.843 j
	3	71.00 ij	151.67 d	29.037 n	21.380 pqr	24.477 j	2.845 n
	4	76.33e-h	152.33 cd	41.720bc	22.527 nop	49.73 a	3.014 m
	5	74.00 g-j	155.33 a	36.363fgh	20.573 qr	26.533 h	2.956 mn
	6	84.33abc	141.00 f	33.457 jk	22.017 opq	23.393 k	3.079 m
	7	85.00 ab	153.00 cd	37.000def	21.247 pqr	40.747 c	2.545 o
	8	78.00d-g	148.00 e	35.353 hi	31.350 l	33.100 f	2.847 n
	9	76.33e-h	153.00 cd	31.263 m	33.940 k	23.517 k	1.875 q
	10	72.67hij	155.00 a	49.447 a	21.343 pqr	42.150 b	2.961 mn
	11	79.33def	155.00 a	42.177 b	22.020 opq	17.633 m	2.201 p
	12	66.333kl	152.00 cd	37.150def	20.190 r	35.933 d	1.700 r
	13	82.67bcd	154.67ab	28.580 n	23.697	22.417 l	3.517 l
	14	82.00bcd	153.33bc	32.807 kl	28.000 m	25.200 i	3.547 l
	15	88.000 a	141.00 f	40.833 c	31.893 l	35.377 e	5.647 de
	16	87.333 a	153.00cd	36.717efg	30.943 l	35.193 e	4.988 g
	17	89.000 a	149.00 e	34.163 ij	31.437 l	28.037 g	3.598 kl
mean		74.458	132.375	32.091	36.946	19.086	4.332

- Means followed by the same letters for each character have no significant difference.

seasons, as needed 103.67 day from planting to flowering, followed by genotypes (15) SETTAT-85, (7) SALE-7 and (17) KHEMISSET-1in the 1st season also. For other characters, such as, NGS, 1000GW, LA and GW, the genotypes (10) SDRAA-1 in the 2nd season, (3) NS732 /HER //ARRIHANE-/3/REGRAG-1in the 1st season, (4) QAFZAH-31 in the 2nd season and (17) KHEMISSET-1in the 1st season recorded higher values of (49.447 seed), (55.283 gn), (49.73) and (8.194 ton/ha) respectively, with significant differences from all other genotypes for each character. Concludes from the foregoing, that the instability of the GY means and due to genetic differences and environmental fluctuations.

(3) Components of variance and heritability:

The significant mean square of genotypes and seeding rates (Table 2), genotypes and seasons (Table 6) and significant interactions between them for all of the studied characters indicating that there were significant variations between genotypes and environmental conditions represented by seeding rates and seasons, It seems through mean square values that there are differences in the relative importance of each of the environments (seeding rates or seasons), genotypes and interaction between them towards different qualities, as can be seen from Table 2, that the differences attributed to genotypes were larger than those belonging to the seeding rates for all characters, the opposite was true among seasons and genotypes (Table 6). The mean square of genetic-environment interaction (Tables 2 and 6), although its high significant, but it was less than it was in genotypes, seeding rates and seasons for all studied characters, this shows there were differences in the degree of genotypes adaptation to environmental conditions and for all of characters. It appears from Table 2, that the coefficient of variability of the LA, which amounted to 4.281% was greater than it is in other characters, and it shows that the change in the rating seed cause the largest differences in LA equivalent to twice what happened for NGS, 1000GW and GY, and three times in that for happened for PH and NDF. The coefficient of variability values in Table 6, indicated that the different growing season caused the largest variations in PH, followed by NGS, 1000GW and GY, and least variations for LA and NDF. Despite what has been discussed above, the results of other researches suggesting that values of the coefficient of variability were not fixed for various studies, the reason may be due to the differences between the crops, genotypes or environmental conditions adopted by researchers in different studies (Budak, 2000 and Dawod and Al-Layla, 2008). Evidenced by the results in Tables 1 and 2 also, that the genetic variance was greater than the variance return to genotype-environment interaction for PH and NDF, and in contrast for other characters, for this reason, it is

noticed that the broad sense heritability was high for PH (95.551% and 56.667%) and NDF (79.291% and 63.099%) and low for other characters (ranged from 31.193% to 48.532%). These results indicate that the characters NSPS, 1000GW, LA and GY were more sensitive to environmental changes as compared with PH and NDF. These results are consistent with the findings of Aycicek and Yildirim (2006) similar for GY, NGS and 1000GW, Dawod and Al-Layla (2008) for PH and NDF and Laghari et al., (2010) for NGS.

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بجهئینان وجوداهی یێن بو پێکهاتهیێن بوماوەی ژ ئاریێ نانی ل دەف ئاستێن توڤی یێن جودا جودا

پوختە

ئاستێن توڤان هاتنە هەلبژاردن (100 و 120 و 140 کگم بو هەر هێکتارەکێ) لسەر بەرهەمێ دندکان و هندەك پێکهاتێن وان (بلندیا رووەکی وهژمارا روژێن کولیلکبوونێ وهژمارا دندکێن ب گولیێ ڤە وکێشا 1000 دندکان و رووبەرێ بەلگی) بو شازدە پێکهاتێن بو ماوەیی هاتیە وەرگرتن ژ گەنمێ نانی زێدەباری جورێ خوّمالّی (ئازادی)، وئەڤ چەندە ژی هاتیە ئەنجامدان ل ئیزگەهێ ڤەکولینێن فاکولّتیا چاندن ودارستانێ ل زانکویا دهوك دا د ما وێ وەرزێ چاندنێ 2011 – 2012، وهەلسەنگاندنا پێکهاتێن بو ماوەیی یێن وەرگرتی بێی جورێ خوّمالّی د ماوێ وەرزێن چاندنێ (2010 – 2011 و 2011 – 2012) ب تێکڕایێ توڤێن 140 کگم بو هەر هێکتارەکێ، ب بکارئینانا دیزاینا بەروکی یا بەرەلایی یا تەڤاڤ ب سێ بارە کرن. کو کارتێ:رنا تێکراییێن توڤ و وەرز وپێکهاتێن بوماوەیی بوّ هەمی سەخلەتان ژ بلی کێشا 1000 دندکان دباریێ تێکڕاییێن توڤان دا. تێکەلبوون دیاربوو دناڤبەرا پێکهاتێن بوماوەیی وتێکراییێن توڤان دا و پێکهاتێن وبماوەیی و وەرزێن جیاواز یێن بلند بوّ هەمی ساخلەتان، هژمارا روژێن کولیلکبوونێ تێ نەبت لدەمێ تێ:هلبوونا جور وتێکراییێن توڤان. کو ناڤەندێن بلندیا رووەکی وهژمارا روژێن کولیلکبوونێ وکێشا 1000 دندکان وبەرهەمێ دندکێن بلند لدەمێ تێکرایێ بلندیێ توڤان (140 کگم بوّ هەر هێکتارەکێ)، بەلێ پا ناڤەندێن هژمارا دندکێن بگولیێ ڤە و رووبەرێ بەلگی یێ بلند دگەل کێمترین تێکڕایی بوّ توڤان (100 کگن بوّ هەر هێکتارەکێ). دناڤبەرا پێکهاتێن بوماوەیی، ئەڤ پێکهاتە بەرهەمهاتن: SETTAT-85 و SALE-7 و KHEMISSET-1 رووەکێن بلندتر وبەرهەمدارتر ب دندکان د هەر هێکتارەکێ دا، وپێ:هاتا SETTAT-85 بسەرکەفت لسەر هەمی پێکهاتان د هژمارا روژێن کولیلکبوونێ دا، وهەر وەسا هەردوو پێکهاتێن JAWAHIR-13 و KHEMISSET-1 ب بلندترین کێش بو 1000 دندکان دیاربوو. ود باریێ تێکەلبوونا پێکهاتێن بوماوەیی دا دگەل هەر ئێك ژ تێکڕاییێن توڤ و وەرزان، گەهشتە بلندترین تێکڕایێ بەرهەمێ دندکان 5,647 تەن بو هەر هێکتارەکێ د پێ:هاتا بوماوەیی SETTAT-85 دا دگەل تێکڕایێ بلندیێ توڤان (140 کگم بوّ هەر هێکتارەکێ) وهەر وەسا بوّ پێکهاتا بوماوەیی KHEMISSET-1 د وەرزێ چاندنێ 2011 – 2012 دا. کو بوماوەبوون ب ڕامانەکا بەرفرەهتر یا بلندە بوّ ساخلەتێن بلندیا رووەکی وهژمارا روژێن کولیلکبوونێ ونزمترینێ وان بوّ ساخلەتێن دی ترێ.

الأداء والتباينات لتراكيب وراثية من حنطة الخبز عند معدلات بذار مختلفة

الخلاصة

تم اختبار تأثير معدلات البذار (100 و 120 و 140 كغم للهكتار) على حاصل الحبوب وبعض مكوناته (عدد الحبوب بالسنبلة ووزن 1000 حبة) والمساحة الورقية وأرتفاع النبات وعدد الايام للتزهير لستة عشر تركيب وراثي مدخل من حنطة الخبز اضافة الى الصنف المحلي (آزادي)، وذلك في محطة بحوث فاكولتي الزراعة والغابات بجامعة دهوك خلال الموسم الزراعي 2011–2012، وتقييم التراكيب الوراثية المدخلة بدون الصنف المحلي خلال الموسمين الزراعيين (2010–2011 و 2011–2012) بمعدل بذار 140 كغم للهكتار^{2} باستخدام تصميم القطاعات العشوائية الكاملة بثلاثة مكررات. كان تأثير معدلات البذار والمواسم والتراكيب الوراثية معنوياً للصفات جميعها ما عدا وزن 1000 حبة في حالة معدلات البذار. ظهر التداخل بين التراكيب الوراثية ومعدلات البذار وبين التراكيب الوراثية والمواسم معنوياً عالياً للصفات جميعها باستثناء عدد الايام للتزهير في تداخل الاصناف ومعدلات البذار. كانت متوسطات ارتفاع النبات وعدد الايام للتزهير ووزن 1000 حبة وحاصل الحبوب عالية عند المعدل الاعلى للبذار (140 كغم للهكتار)، بينما كانت متوسطات عدد الحبوب بالسنبلة والمساحة الورقية عالية عند اقل معدل للبذار (100 كغم للهكتار). من بين التراكيب الوراثية ، انتجت التراكيب SETTAT-85 و SALE-7 و KHEMISSET-1 نباتات اكثر ارتفاعاً وأكثر حاصل للحبوب بالهكتار، وتفوق التركيب SETTAT-85 على التراكيب جميعها في عدد الايام للتزهير، واظهر التركيبين JAWAHIR-13 و KHEMISSET-1 اعلى وزن للألف حبة. وفي حالة تداخل التراكيب الوراثية مع كل من معدلات البذار والمواسم، بلغ اعلى معدل لحاصل الحبوب 5.647 طن للهكتار في التركيب الوراثي SETTAT-85 عند المعدل العالي للبذار (140 كغم للهكتار)، وكذلك للتركيب الوراثي KHEMISSET-1 في الموسم الزراعي 2010–2011. كان التوريث بالمعنى الواسع عالياً لصفتي ارتفاع النبات وعدد الايام للتزهير ومعتدل لصفتي ارتفاع النبات وعدد الجبوب في السنبلة.

GENETIC VARIANCE, HERITABILITY, CORRELATION AND PATH COEFFICIENT ANALYSIS IN DURUM WHEAT (TRITICUM DURUM DESF.)*

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ABSTRACT

Five parents and ten F1 crosses were grown in RCBD design with three replications 2010. Correlation ,Path coefficient analysis and heritability were estimated for days to 75% flowering, plant height, flag leaf area, number of spikes/plant, spike length, number of effective tillers/plant, number of grains/spike, 1000 grain weight, biological yield/plant, grain yield/plant, harvest index and protein percent. Broad sense heritability was found to be high in all characters; while high narrow sense heritability was found for days to 75% flowering and moderate for protein percent. Presence of gene action in traits like plant height, flag leaf area, spikes/plant, number of grains/spike, 1000-grain weight and grain yield. Significant and positive correlation was found between grains yield/plant and each of plant height, spike length, number of spikes/plant, number of grains/spike, 1000 grain weight, harvest index biological yield/plant, flag leaf area and number of effective tillers/plant. Path analysis revealed that number of spikes/plant had highest direct effect on grain yield/plant indirect effect through other characters which was used as index for the selection of high grain yield/plant.

KEY WORDS: wheat, half diallel cross, correlation, path coefficient analysis.

INTRODUCTION

Durun wheat (Triticum durum desf.) is an economically important crop and widely grown in most part of the word and Kurdistan Region. It cultivated on 10-11% of the world wheat areas and accounting about 8% of total wheat production (Ganeva et al., 2011). The development of high yielding varieties with desirable quality characteristics is the major objective in durum wheat breeding program. Analysis of variability among the traits and the association of particular among traits contributing to yield of a crop would be great importance in planning successful breeding program (Mary and Gopalan, 2006). Genetic variability among durum wheat genotype can be estimated based on qualitative and quantitative traits. The choice of parents are of paramount importance in breeding program for effective selection , information on nature and magnitude of variation in population, association of character with yield and among themselves crosses. Correlation can be expressed by the nature of association between yield and their components and between each pair of components themselves. In a plant, breeding program correlation offers an important role to the breeder by providing information to predict and select the character with low heritability through their type of association and the degree with other characters having high heritability (Kashif andKhaliq 2004). Hama, (2006)observed that narrow sense heritability value was low for studied characters plant height, grains yield/plant, days to maturity, number of tillers/plant, number of spikes/plant, spike length, number of spikelets /spike, number of grains/spike, 1000 grain weight, biological yield/plant and harvest index. Ahmad and Al-Taweal, (2007) studied genotypic correlation in wheat and observed that grain yield/plant had significant and positive association with harvest index, grains yield/plant, biological yield/plant, number of spikes/m² and protein percent. Path analysis supposes presence of linear relationship between the cause and effect. Dewey and Lu (1959) reported that the advantage of path analysis is that it permits the partitioning of the correlation coefficient into direct effect of predictor variable upon its response variable and indirect effect of a predictor variable on the response variable through another predictor variable. Nofouzi*et al.*, (2008)1000-grain weight, spike length and number of grains/spike had highest direct positive effects on grains yield/plant. Dogan, (2009) observed that plant height,1000-grain weight, number of

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grains/spike and test weight had significant direct effect on grains yield/plant.

The main objective of the present study is to develop variety with high yielding ability by estimated simple correlation among characters and determine the traits which have higher direct and indirect effects on grain yield of durum wheat.

Materials & Methods

Five varieties of durum wheat (Kokoret c-71, LD357E, Crezo, Cimeto, Um-Rabey-5). Were crossed in all combination excluding reciprocal to produce ten hybrids, which were used as the experiment materials. Which are sown with its parents in growing season, in field of college of Agriculture, University of Duhok (2010).At maturity, five plants from each genotype were taken at random for recording observation, the characters are days to 75% flowering, plant height, flag leaf area, number of spikes/plant, spike length, number of effective tillers/plant, number of grains/plant, 1000 grain weight, biological yield/plant, grain yield/plant, harvest index and protein percent. Analyzed according Griffing (1956).Broad sense heritability considered high when it is more than 60%, it is medium between 40% - 60% and low when it is less than 40% , (Ali, 1999)$h^2.b.s = \frac{\sigma^2 G}{\sigma^2 P}$

Narrow sense heritability considered high when it is more than 50%, medium in the range 20% - 50% and low when the it is less than 20% (Al- Auddari and Mohammed, 1999).

$h^2.n.s = \frac{\sigma^2 A}{\sigma^2 P}$

the Simple correlation among traits was estimated using the following formula:

$$r = \frac{\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{n}}{\sqrt{\Sigma X^2 - \frac{(\Sigma X)^2}{n}} \times \sqrt{\Sigma Y^2 - \frac{(\Sigma Y)^2}{n}}}$$

Where,

n = number of the treatments (observations).

r = correlation coefficient value.

The correlation coefficients between grain yield (Y) and each of plant height(X1), number of tillers (X2), spike length (X3), number of spikes/plant (X4), number of grains/spike (X5) and 1000 grain weight was divided into direct and indirect effects according to the method outlined by (Al-Rawi, 1987). Dewey and Lu (1959) have suggested the following scale to determine the importance of direct and indirect effects:

Value of direct or indirect effect	rate of scale
Negligible	0.00 - 0.0
Low	0.10 - 0.19
Moderate	0.20 to 0.29
High	0.30 to 0.99
Very high	More than one

RESULTS AND DISCUSSION

Genetic variance, Heritability and Correlation

The results in the **table (1)** showed a high heritability in broad sense for all characters, while it was moderate for spike length. These indicate low environment of variance, and the variance between the characters belongs to genetic.

High Heritability in narrow sense was found for days to 75% flowering, moderate for protein percent and low for plant height, flag leaf area, number of spikes/plant, spike length, number of grains/spike, number of effective tillers/plant, 1000 grain weight, grain yield/plant, biological yield/plant and harvest index(Hassan*et al.*, 2008).

Dominance genetic variance was more than additive genetic variance in for all characters. This indicates the preponderance of over dominance in the inheritance of these characters that mean these characters can be improved by hybridization (Hassan *et al.*, 2008).

Table (**2**) showed simple correlations coefficients between all studied characters in durum wheat. Highly significant and positive correlation was shown between plant height and spike length, while significant and positive correlation was shown between plant height and each of number of grains/spike, biological yield/plant and grain yield/plant, while negative non significant correlation was found between plant height and protein percent. Significant and positive correlation was found between spike length and number of grains/spike, biological yield/plant, flag leaf area and grain yield per plant, whereas negative correlation was between spike length and protein percentage. Highly significant and positive correlation was shown between a number of spikes/plant and each of grain yield/plant and biological/plant, while negative non-significant correlation was exhibited between a number of spike/plant and protein percent. The number of grains/spike was highly significant and positively correlated with 1000-grain weight, biological yield/plant and grain yield/plant. 1000 grain weight significantly

and positively correlated with biological yield/plant and grain yield/plant. Harvest index had significant and positively correlation with grain yield/plant. Highly significant and positive correlation was exhibited between biological yield/plant and number of productive tillers/plant and grain yield/plant, whereas significant and positive correlation was shown between biological yield/plant and flag leaf area. Positive and highly significant correlation was observed between the number of productive tillers/plant and the grain yield/plant, while negative non-significant correlation was observed with protein content. Flag leaf area had significant and positive correlation with grain yield/plant. Similar results have been reported by other researcher (Ahmad and Al-Taweal, 2007).

Path coefficient analysis:

The partitioning of correlation coefficients between grain yield/plant and some affecting characters to direct and indirect effects. Was presented in the table **(3)** plant height exhibited a positive direct effect but not important on grain yield/plant, and positive (non important) indirect effects through number of tillers/plant, 1000grain weight, and low through spike length, number of spikes/ plant, number of grains/spike. The number of tillers/plant showed a positive (non-important) direct effect on grain yield/plant, and positive moderate indirect effect through number of spikes/plant, number of grains/plant and 1000 grain weight. The trait spike length has a positive low direct effect on grain yield/plant, while positive low indirect effect was observed through, number of spikes/plant and number of grains/spike and not important through other characters. It has been observed that the number of spikes/plant have high and positive direct effect on grain yield/plant, and positive low indirect effect through number of grains/spike and non important other characters the total correlation was of high significant. Number of grains/plant showed positive moderate direct effect on grain yield/plant, positive low indirect effects through number of spikes/plant and 1000 grain weight and non important through other characters. Finally, the 1000 grain weight recorded positive moderate direct effect on grain yield/plant, and positive low indirect effect through number of spikes/plant and number of grains/spike, but non important through other characters the total correlation was of high significant difference.

It was concluded that number of spikes/plant had positive high direct effect on grain yield and positive higher indirect effects through all other characters, then, this character could be used as an index in the selection of high grain yield by plants followed number of grain/spike and 1000-grain weight. These results are inconformity with (Nofouzi et al., 2008 , Dogan, 2009).

CONCLUSION

It is concluded for all characters have high broad sense heritability, while high narrow sense heritability was found for days to 75% flowering and moderate for protein percent. Path coefficient analysis revealed that number spikes/plant had highest direct effect on grain yield/plant and indirect effect through other characters when was used as index for the selection of high grain yield/plant.

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Table (1): Additive (σ^2 A), Dominance (σ^2 D), environmental (σ^2 E) and phenotypic (σ^2 p) variance genetic ,heritability in broad sense (h.b.s) and heritability in narrow sense (h.n.s) for studied characters.

parameters	Days to 75% flowering	Plant height (cm)	Flag leaf area (cm^2)	Number of spikes/plant	Spike length (cm)	Effective tillers/plant	Number grains/spike	1000grain weight (g)	Biological yield/plant (g)	Grains yield/plant (g)	Harvest index %	protein %
σ^2 A	5.04	5.07	2.74	0.23	0.01	0.23	7.96	5.81	22.10	10.43	0.00	0.52
	2.91±	3.11±	2.14±	0.16±	0.02±	0.16±	4.94±	3.44±	14.87±	2.47±	0.22±	0.32±
σ^2 D	4.90	20.76	15.87	4.33	0.24	4.33	77.31	35.52	434.83	190.14	10.09	0.99
	2.00±	8.92±	2.14±	1.828±	0.14±	1.82±	32.41±	14.72±	182.71±	78.61±	4.66±	0.46±
σ^2 E	0.00	3.29	9.99	0.43	0.27	0.43	6.26	1.59	37.89	7.28	3.92	0.42
	0.00±	0.84±	2.58±	0.111±	0.07±	0.11±	1.61±	0.41±	9.78±	1.88±	1.01±	0.10±
σ^2 p	9.94	29.12	28.60	4.99	0.52	4.99	91.53	42.92	494.82	207.87	14.00	1.93
h.b.s	100.00	88.70	65.07	91.38	49.39	91.38	93.15	96.27	96.49	92.34	71.98	78.25
h.*n.s*	50.72	17.41	9.58	4.47	3.84	4.47	8.70	13.55	5.02	4.46	--------	27.07

Table (2): Simple correlation coefficient between yield and other traits in durum wheat.

characters	Number of spikes/plant	Spike length (cm)	Number of grains/spike	1000-grain weight (g)	Harvest index	Biological yield/plant (g)	Days to 75% flowering	Flag leaf area (cm²)	Productive tillers/ plant	Protein %	Grain yield/plant (g)
Plant height (cm)	0.36	0.65**	0.53*	0.28	0.17	0.51*	0.07	0.25	0.36	-0.12	0.52*
Number of spikes/plant		0.33	0.44	0.36	0.32	0.70**	0.29	0.31	1.00	-0.02	0.70**
Spike length (cm)			0.61*	0.35	0.21	0.56*	0.22	0.58*	0.33	-0.07	0.57*
Number of grains/spike				0.67**	0.44	0.63**	0.43	0.46	0.44	0.16	0.70**
1000-grain weight (g)					0.35	0.58*	0.40	0.36	0.36	0.14	0.61*
Harvest index						0.29	0.24	0.13	0.32	0.25	0.53*
Biological yield/plant (g)							0.32	0.54*	0.70**	0.04	0.95**
Days to 75% flowering								0.44	0.29	-0.08	0.37
Flag leaf area (cm²)									0.31	-0.10	0.53*
Productive tillers/plant										-0.02	0.70**
Protein %											0.10

***** and ****** significant difference at level 0.05 (r = 0.49) and 0.01 (r =0.62) respectively.

Table (3): direct and indirect effects of different characters on grain yield in durum wheat.

1	**Effect of plant height (X_1) on yield**		4	**Effect of number of spikes per plant (X_4) on yield**	
	direct	0.07183		direct	0.42172
	Indirect through number of tillers (X_2)	0.012057		Indirect through plant height (X_1)	0.025952
	Indirect through spike length (X_3)	0.102307		Indirect through number of tillers (X_2)	0.019648
	Indirect through number of spikes per plant (X_4)	0.152367		Indirect through spike length (X_3)	0.052289
	Indirect through number of grains per spike (X_5)	0.121142		Indirect through number of grains per spike (X_5)	0.101236
	Indirect through 1000 grain weight (X_6)	0.063529		Indirect through 1000 grain weight (X_6)	0.081548
	Total correlation	0.5232*		Total correlation	0.7024**
2	Effect of number of tillers (X_2) on yield		5	Effect of Number of grains per spike (X_5) on yield	
	direct	0.02802		direct	0.22801
	Indirect through plant height (X_1)	0.030908		Indirect through plant height (X_1)	0.038163
	Indirect through spike length (X_3)	0.041201		Indirect through number of tillers (X_2)	0.006627
	Indirect through number of spikes per plant (X_4)	0.29571		Indirect through spike length (X_3)	0.096747
	Indirect through number of grains per spike (X_5)	0.053924		Indirect through number of spikes per plant (X_4)	0.187244
	Indirect through 1000 grain weight (X_6)	0.052185		Indirect through 1000 grain weight (X_6)	0.151933
	Total correlation	0.7010		Total correlation	0.7087**
3	Effect of spike length (X_3) on yield		6	Effect of 1000 grain weight (X_6) on yield	
	Direct	0.15660		direct	0.22552
	Indirect through plant height (X_1)	0.046927		Indirect through plant height (X_1)	0.020235
	Indirect through number of tillers (X_2)	0.007372		Indirect through number of tillers (X_2)	0.006484
	Indirect through number of spikes per plant (X_4)	0.140812		Indirect through spike length (X_3)	0.055436
	Indirect through number of grains per spike (X_5)	0.140865		Indirect through number of spikes per plant (X_4)	0.152494
	Indirect through 1000 grain weight (X_6)	0.079834		Indirect through number of grains per spike (X_5)	0.15361
	Total correlation	0.5724*		Total correlation	0.6138**

پوختە

پێنج باب و دەھ تێکەلوك F1 هاتنە چاندن بریا RCBD سی جارکی ل سالا 2010. هەڤبەست و شی کرنا ری زەلیانێ و رەڤشتێ هاتنە هژمارتن بو سالوخەتێن هژمارا ڕوژین بو گولی دانێ 75% و بلندیا بنا روەکی و روێ بەلگی و هژمارا گولیا /بو هەر بنەکا روەکی و دریژیا گولیێ و هژمارا تایا/ بنا روەکی و هژمارا دندکا/گولیا و سەنگا 1000 دندکا و بەرێ بایولوژی/بنا رروەکی و بەرێ گەنمی/ بنا روەکی و ریبەرێ دورنیێ و ریژا پروتینی. ریژا رەڤشتێ ب رامانا بەرفرەھ یا بلند بو بو ھەمی سالوخەتا ، ریژا رەڤشتێ ب رامانا بەرتەنگ یا بلند بوو بو سالوخەستا هژمارا ڕوژین بو گولی دانێ 75% و یا نافەراست بوو بو سالوخەتا ریژا پروتینی. کارتێکرنا جینی ھەبوو ل سەر سالوخەتن بلندیا بنا روەکی ،روێ بەلگی ، هژمارا گولیا /بو هەر بنەکا روەکی، هژمارا دندکا/گولیا ، سەنگا 1000 دندکا و بەرێ گەنمی/ بنا روەکی. هەڤبەستە پوزیتیڤ و بەرچاڤ لناڤبەرا بەرێ توڤی/بنا رروەکی وھەر ئیکی ژ بلندیا بنا رروەکی و هژمارا گولیا /بو هەر بنەکا روەکی دریژیا گولیێ و هژمارا دندکا/گولیا و سەنگێ 1000 دندکا و ریبەرێ دورنیێ و بەرێ بایولوژی/بنا رروەکی و بەرێ گەنمی/ بنا روەکی و روێ بەلگی و هژمارا تێن چالاك/بنا رروەکی. شێکرنا ری زەلیانێ دیارکر کو هژمارا گولیا/بنا رروەکی کارتێکرنەکا ئێکسەر و بلند ل بەرێ دندکا/ رروەکی یا ھەی و دیشێن پشت پەستنی ل سەر بکەین وکو ریبەری ھەلبژارتێنی بوو بەری بلند/ رروەکی.

الخلاصة

خمسة اباء و عشرة هجن F1 تمت زراعتها بتصميم RCBD بثلاث مكررات في عام 2010 . الارتباط ومعامل تحليل المسار و التوريث تم تقديرها لصفات عددايام الى 75% تزهير، ارتفاع النبات ، مساحة ورقة العلم ،عدد السنابل/ النبات ، طول السنبلة ، عدد تفرعات الفعالة/ النبات ، عدد الحبوب / السنبلة ، وزن 1000 حبة ،الحاصل البايولوجي/ النبات ، حاصل الحبوب/ النبات ، دليل الحصاد ونسبة البروتين. كان التوريث بالمعنى الواسع عالية لجميع الصفات ،اما التوريث بمعنى الضيق كانت عالية لصفة عدد ايام الى 75% تزهير، و متوسطة لصفة نسبة البروتين، بينما وجود تأثير الجين لصفات ارتفاع النبات، مساحة ورقة العلم ، عدد السنابل/ النبات، عدد الحبوب/السنبلة، وزن 1000 حبة، حاصل الحبوب/ النبات. وجود الارتباط موجبا و معنويا بين صفة حاصل الحبوب/ النبات و الصفات ارتفاع النبات، و طول السنبلة، عدد الحبوب/ بالسنبلة، وزن 1000 حبة، دليل الحصاد ،الحاصل البايولوجي/ النبات، مساحة ورقة العلم ، عدد تفرعات الفعالة/ النبات. اظهر معامل تحليل المسار لصفة عدد السنابل/ النبات تأثير مباشر وعالي على حاصل الحبوب / النبات و تأثير غير مباشر على بقية الصفات والذي يمكن اعتماد كدليل للانتخاب عالي للحاصل بالنبات.

STUDY OF THE EFFECT OF ANTIMICROBIAL AGENT OF *Pseudomonas aeruginosa* ISOLATED FROM BOVINE INFECTED WOUNDS ON SOME OTHER PATHOGENIC MICROORGANISMS

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ABSTRACT

This study was estimated the ability of extracted supernatant of *Pseudomonas aeruginosa* involved in bovine wounds infectionss to inhibitor the growth of some pathogenic microorganism such as *Candida albicans, Staphylococcus aureus,Escheria.coli* by the action of extracted supernatant of *Pseudomonas aeruginosa* on these tested microorganism ,using disc diffusion test to measuring the inhibition zone of the growth of these tested microorganism. The study showed that the diameter of inhibition zone was 2.0cm, 1.9cm , 1.9 cm for *Candida albicans, Staphylococcus aureus, Escheria .coli* respectively, while no inhibition zone *against Klebsiella pneumonia*e and *Bacillus subtilis* was recorded

KEY WORDS : Antimicrobial agent , Pseudomonas aeruginosa, Staphylococcus aureus, E.coli.

INTRODUCTION

Natural organic compounds produced by microorganisms are an important screening target for a variety of bioactive substances. It can be purified from microbial fermentation and modified chemically or enzymatically for either chemical use or for fundamental studies (Robber,*et.al*.1996).

Today, increase in the number of drug-resistant pathogens, particularly the acquired multi-drug resistant strains, cause serious public health problem throughout the world, (Darabpour,*et.al*.2010) ,Therefore, the need for antimicrobial discovery and better treatments of these infections, particularly in hospitals where resistance is immediately life threatening, is growing more urgent, (Shlaes, *et.a*l.2004) pseudomonads represent the major group of non-differentiating microorganisms that produce antibiotics. *Pseudomonas* spp.implicated in antibiotic production is *Pseudomonas aeruginosa*, were many antibiotic substances produced by this organism such pyocyanin, pyrolnitrin, pyverdin and pseudomonic acid have been produced on a commercial basis (Leisinger and Margraff,1979). It has been demonstrated that some secondary metabolites produced by *Pseudomonas aeruginosa* confer obvious selective advantages to the producer organisms in their natural environment. For example, slime production by *Pseudomonas aeruginosa* enables chest colonization in patients with cystic fibrosis, (Evans and Linker,1973, Govan,*et.al*,1979).

Pseudomonas aeruginosa synthesized a characteristic blue-green, chloroform blue compound called pyocyanin (1- hydroxys-methel-phenazine) (Hasset, *et.al*. 1992). Pathophysiological effects of *Pseudomonas aeruginosa* are often associated with a number of virulence factors secreted by this bacterium, pyocyanin, a low molecular weight phenazine redox pigment (Mavrodi and Thomashow, 2001). ,Ppyocyanin has antibiotic activity against wide variety of microorganisms, which may benefit *Pseudomonas aeruginosa* by elimination of competing microorganisms. pyocyanin used as antimicrobial agent selectively inhibitors for gram-positive and gram-negative bacteria, (Hassan and Fridovich, 1980, Palaniv *et.al*. 2010).

MATERIALS AND METHODS

I-Microbial strains:

These strains were isolated from different clinical cases in Ddepartment of Microbiology / Veterinary Mmdicine College / University of Mosul included:

1. *Pseudomonas aeruginosa* were isolated from bovine wound infections.

2. *Candida albicans*, *Staphylococcus aureus*, *Escheria .coli*, *Klebsiella Pneumoniae*, *Bacillus subtilis*, were isolates from bovine mastitis, these isolates were diagnosed based on morphological and biochemical characteristics according to

Bergey's Manual of Terminative Bacteriology (Holt, *et al.* 1994, Baron, *et.al.*1994).

II-Mass cultivation and antimicrobial assay:

Mass cultivation of *Pseudomonas aeruginosa* was prepared by inoculation a loopful of *Pseudomonas aeruginosa* in four flasks, each containing 100 ml of sterile nutrient broth + 2% glucose, then incubated at 37 C° for 24 hr Old bacterial culture were grown on king medium B (King,et.al.1954).

Flasks were incubated at 25 C° on an orbital shaker at 150 rpm for 48 hr, after that bacterial cells were removed from the culture by centrifugation at 2000 rpm. The supernatant was extracted three times with 1:10 ethyl acetate in a separatory funnel. The ethyl acetate fraction was evaporated to dryness in vacuo, at 40 C° with arotary evaporator and resuspended in 10 ml of chloroform-methonal(20:1)(Essar,et.al. 1990, Rovera,*et.al*.2001).

III- Disc diffusion method:

This method was used to test the microbial sensitivity produced by *Pseudomonas aeruginosa* according to (Atlas,*et.al*.1995) against microorganisms.(*Candida albicans, Staphylococcus aureus,. Escheria coli, Klebsiella pneumoniae,* and *Bacillus subtilis)*

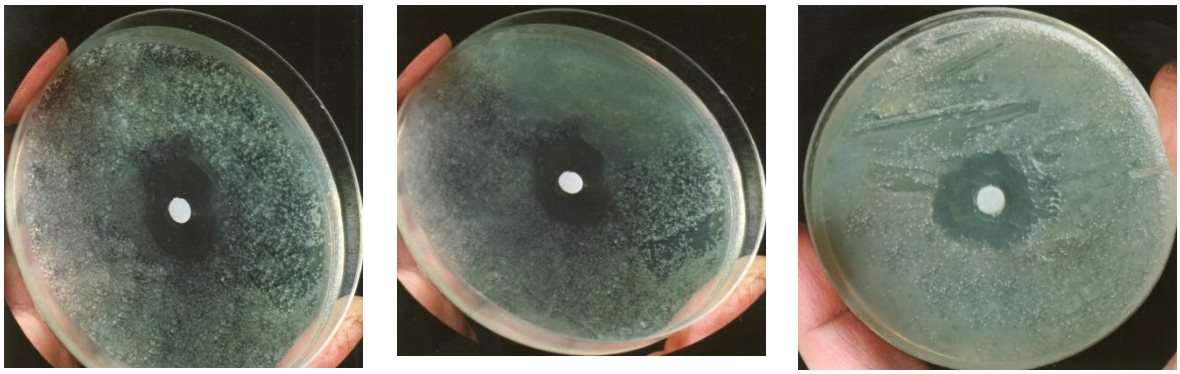
RESULTS AND DISCUSSION

This study showed that the ability of *Pseudomonas aeruginosa* to show inhibition the growth of *Candida albicans*, *Staphylococcus aureus,Escheria .coli* .On other hand , no effect were recorded on other tested microorganism such as *Klebsiella pneumoniae,* and *Bacillus subtilis*.

This study showed that the diameter of inhibition zone of *Pseudomonas aeruginosa* antagonistic productis were 2cm, 1.9cm, 1.9cm *against Candida albicans, Staphylococcus aureu and sEscheria .coli* respectively, table (1) and figure (1),

Table (1): Invitro activity of *Pseudomonas aeruginosa* production against pathogenic microorganisms

Microorganisms	Zone of inhibition (cm)
Candida albicans	2.0
Staphylococcus aureus	1.9
E.coli	1.9
Klebsiella pneumoniae	0
Bacillus subtilis	0



(A) (B) (C)

Fig. (1): zone of inhibition of *Pseudomonas aeruginosa* productis against *Candida albicans* (**A**), *Staphylococcus aureus* (**B**),*Eschrtia .coli* (C) but *Klebsiella pneumonia*, *Bacillus subtilis* there are no zone of inhibition to ward this production of *Pseudomonas aeruginosa*

The our results were in accord with (Jayasmal, *et.al*.1990,Gupta, *et.al*. 2001, Enass and Sweedan 2010).Astudy of *invitro* studies of invitro antagonism have often demonstrated that medium composition strongly affect on production of secondary metabolites and hence act on inhibition pattern exhibited by specific *Pseudomonas* strain (Bushra,*et.al*.2008).

Throughout the last 50 years, antibiotics have been the main treatment modality used to attacked bacterial infections.

Prolonged and indiscriminate use of antibiotics to treat infections in both man and animals has resulted in the rapid emergence of antibiotic resistant bacteria (Filutowicz,*et.al* 2008).

Pseudomonas aeruginosa can produce a variety of inhibitory substances, small antimicrobial substances such as pyocyanin and pyoverdin have been described for *Pseudomonas spp*. (Baron and Rowe,1980 ,Visca,*et.al*.2007).

Our study accord with (Fontoura, *et.al.* 2009),who stated that *Pseudomonas aeruginosa* produced an antibiotic with inhibitory activity observed against *Candida albicans*, *Staphylococcus aureus*s, and *Escheria .coli*.

(Palaniv,*et.al*.2010) showed ethyl acetate extract of *Pseudomonas aeruginosa* exhibited antagonistic activity against *Staphylococcus aureus*, *E.coli*, *Klebsiella pneumonia* and *Enterobacter aerogenes* but no activity against *vibrio cholera* and *Candida albicans*, were demonstrated .

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دراسة تأثير العوامل المضادة للميكروبات لـ *Pseudomonas aeruginosa* المعزولة من حالات التهاب الجروح في الأبقار على بعض الأحياء المجهرية المرضية

الخلاصة

بينت الدراسة قابلية *Pseudomonas aeruginosa* المعزولة من حالات التهاب الجروح في الأبقار على تثبيط نمو بعض الأحياء المجهرية المرضية كـ *Candida albicans*, *Staphylococcus aureus*,*Eschreia.coli* وذلك بفعل الراشح المستخلص من هذه العزلة وقياس قطر التثبيط لهذه الأحياء المجهرية حيث وجد أن القطر التثبيطي 2.0cm و 1.9cm و 1.9cm لـ*Candida albicans* , *Staphylococcus aureus* , *Eschreia.coli* على التوالي بينما لم يسجل أي تثبيط لـ *Klebsiella pneumoniea* , *Bacillus subtilis*.